

(12) UK Patent Application (19) GB (11) 2 083 002 A

(21) Application No 8126953
 (22) Date of filing 7 Sep 1981
 (30) Priority data
 (31) 184787
 (32) 8 Sep 1980
 (33) United States of America (US)
 (43) Application published 17 Mar 1982
 (51) INT CL³ B65B 11/04
 (52) Domestic classification B8C W25 W2
 (56) Documents cited GB 2059906A
 (58) Field of search B8C B8R
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(54) Process and Apparatus for Wrapping Loads in Stretch Film

(57) An apparatus for stretching a web of plastics film above its yield point before wrapping it around a load includes stretching means and force relieving means. In one embodiment the stretching means comprises a roller assembly having two interconnected rollers (34, 36) rotatable by the web as it is drawn off

a film supply (20) upon being wrapped around a load (200) on a turntable (202); the rollers being interconnected so that an upstream one (34) of which rotates slower than the other (36) to produce film elongation between the rollers. The force on the film between the roller assembly and the load (200) is relieved by the action of a positive constant torque device driving the rollers (34, 36), so that the film elongation between the roller assembly and the load is equal to or less than the elongation incurred between the rollers. Since the film has been stretched above its yield point, the film retains a high degree of pre-stretch elongation despite relieving stress from the film between the roller assembly and the load.

In another embodiment the web is stretched by stationary bars (71 to 73) and partially drawn around a roller (36) powered by a positive constant torque device.

FIG. 14

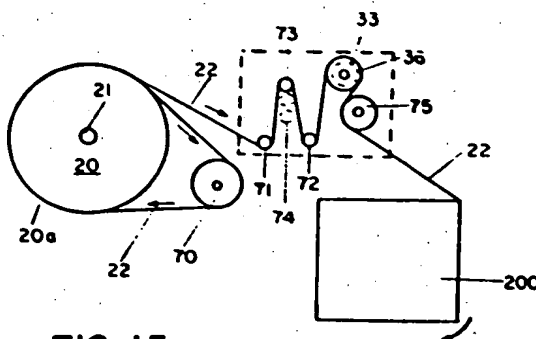
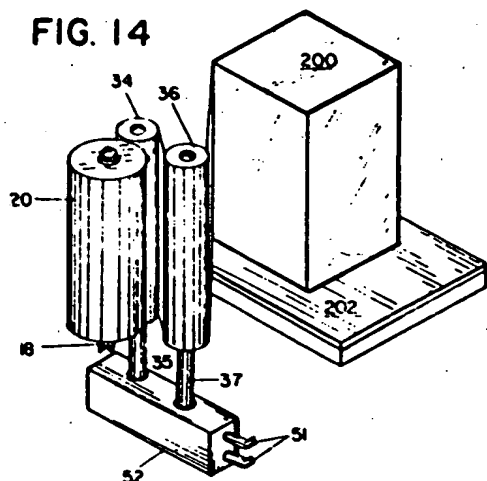


FIG. 15

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FIG. 1

PRIOR ART

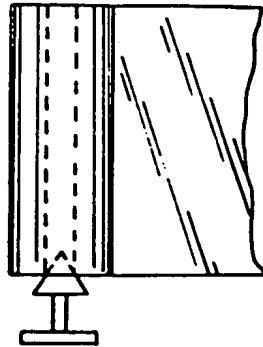


FIG. 2

PRIOR ART

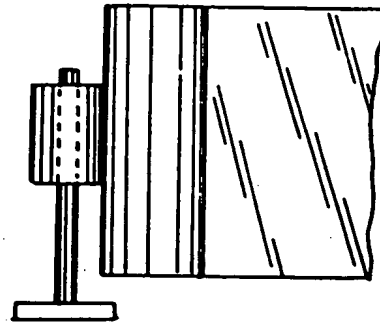
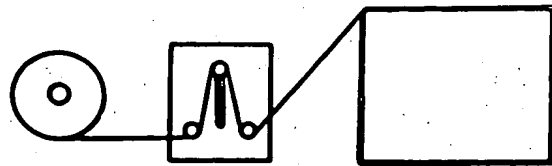
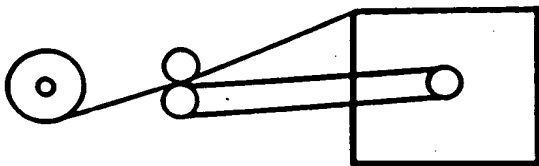


FIG. 4



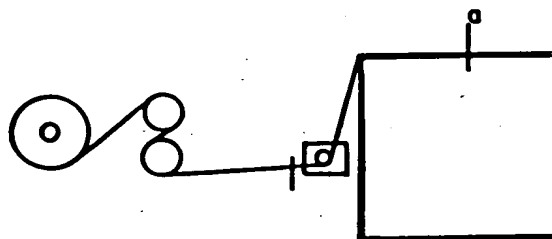
PRIOR ART

FIG. 5

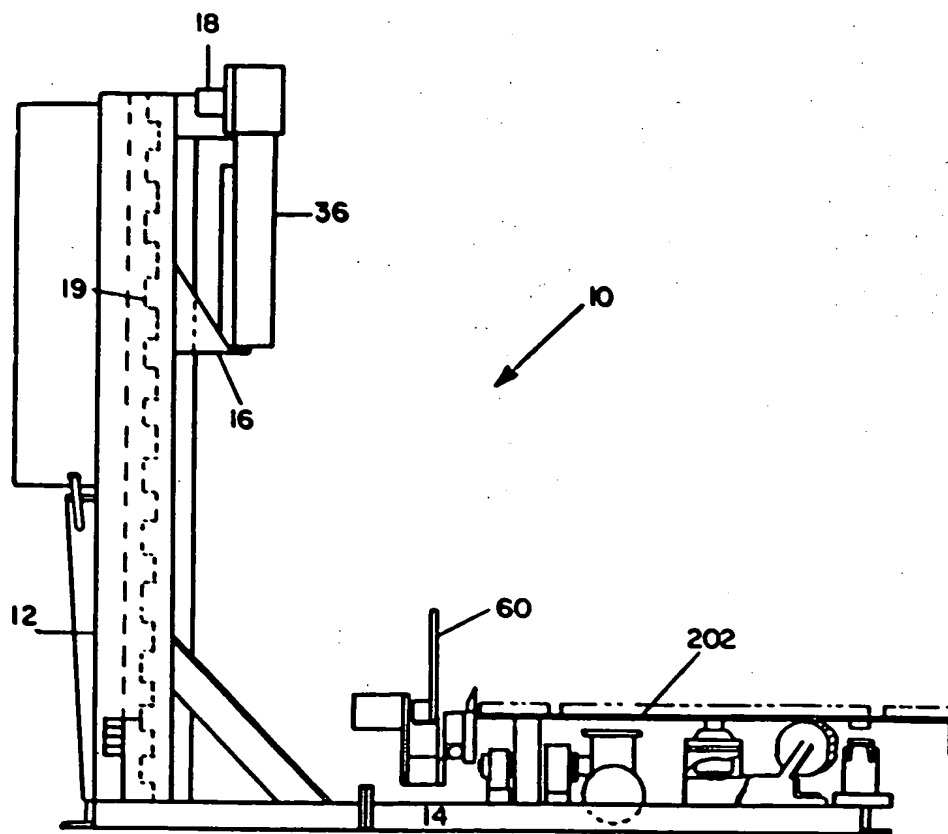
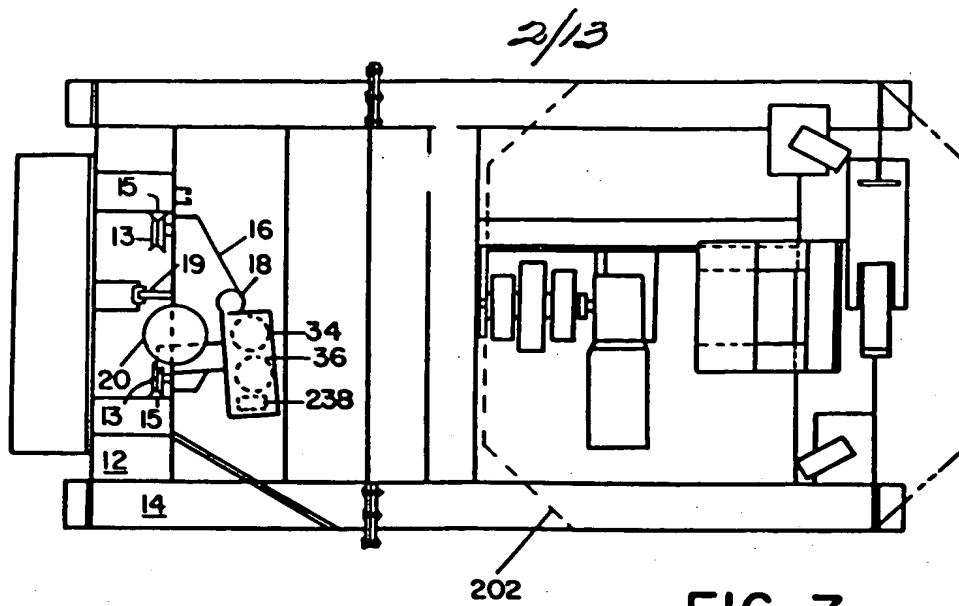


PRIOR ART

FIG. 3

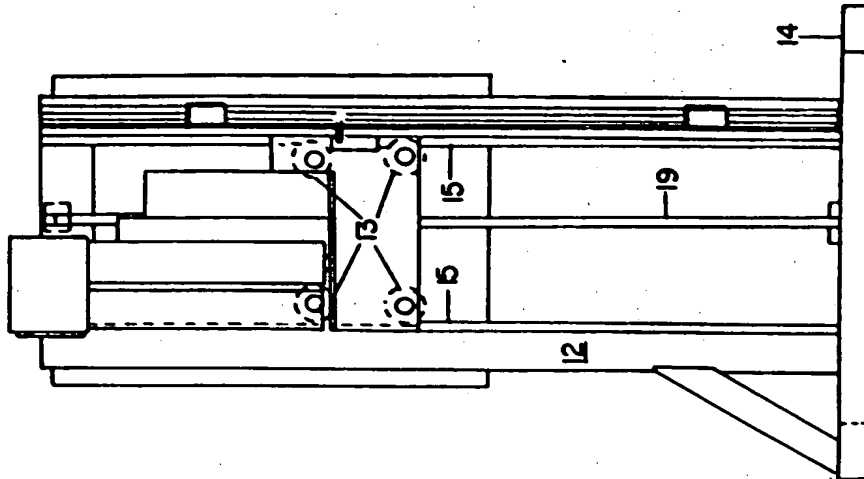


PRIOR
ART

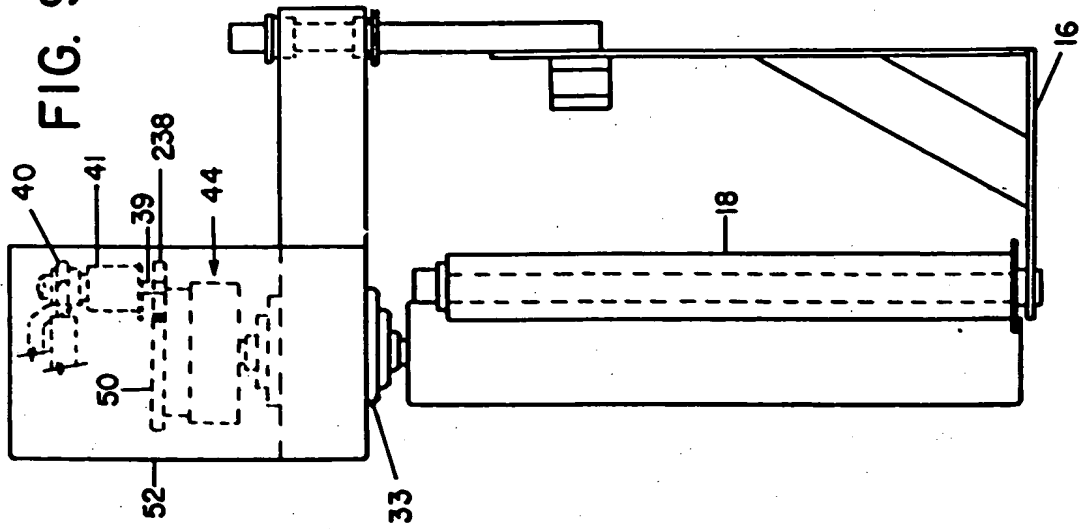


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Fig. 8



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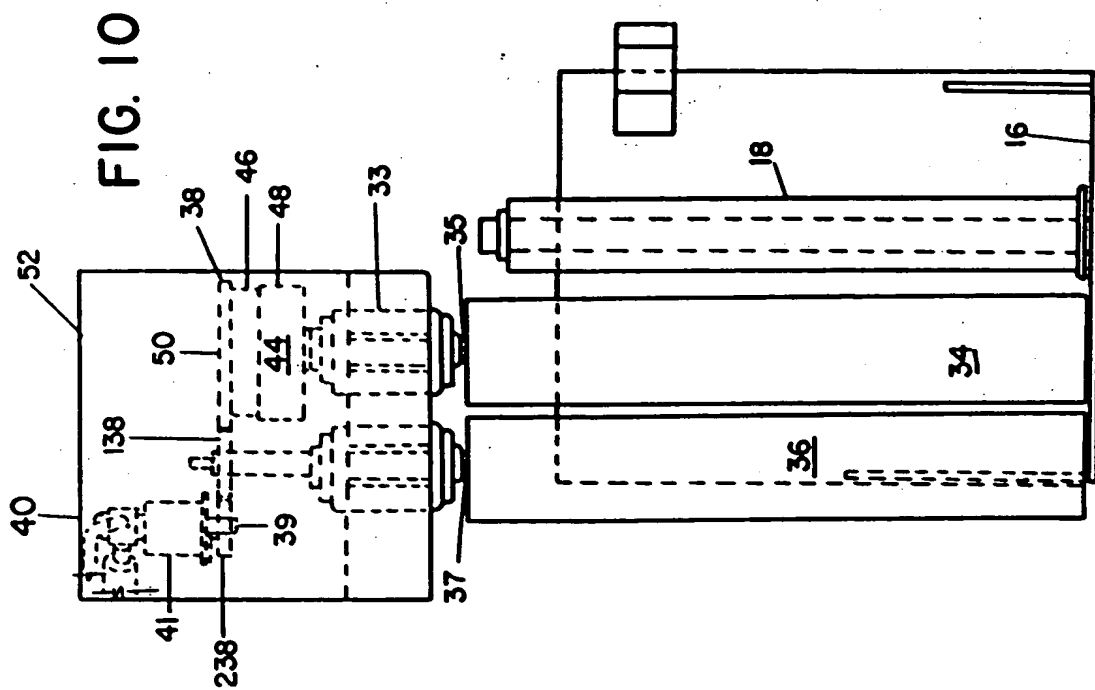


FIG. 10

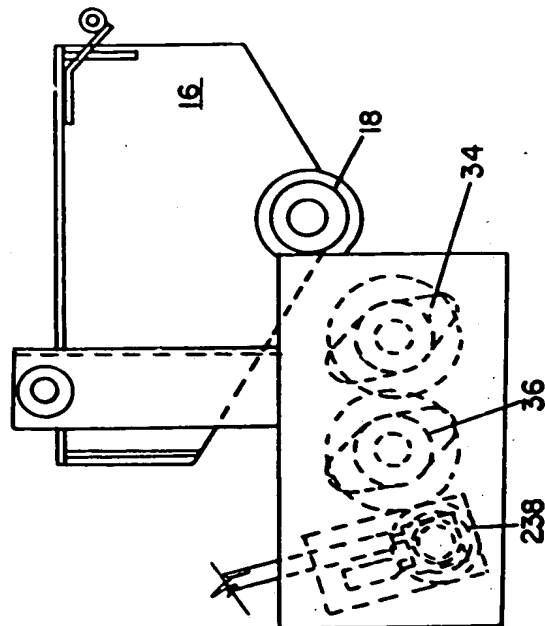


FIG. 11

FIG. 12

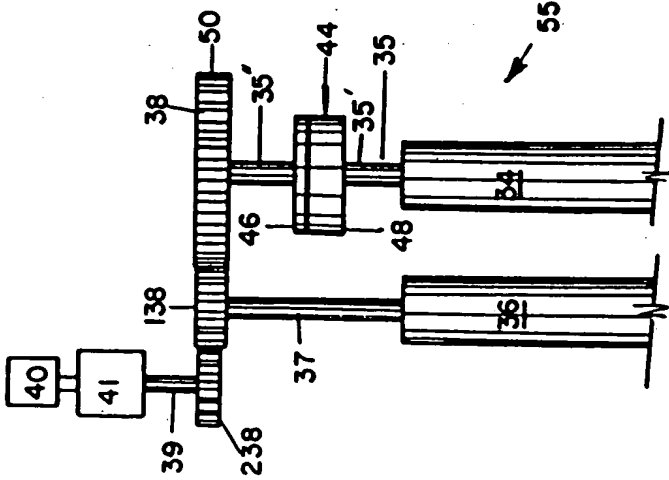


FIG. 13

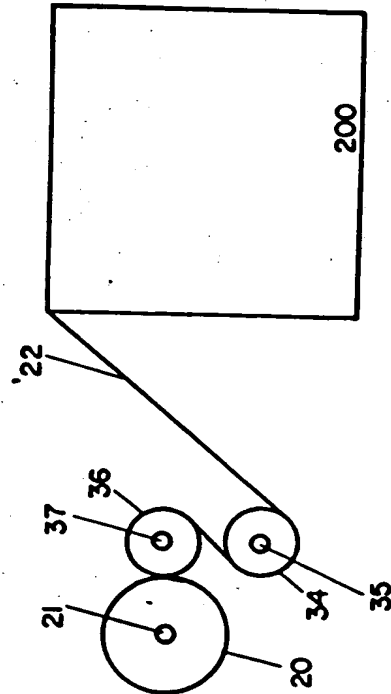
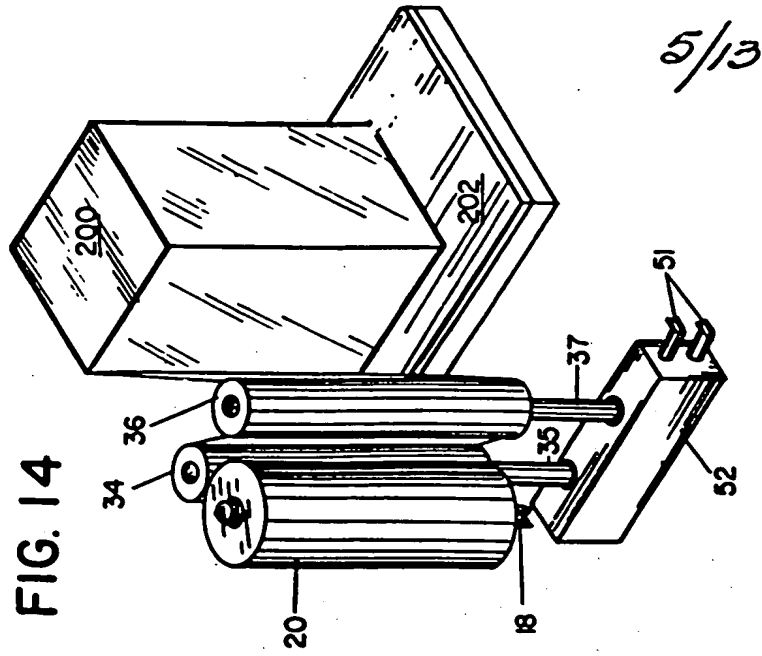


FIG. 14



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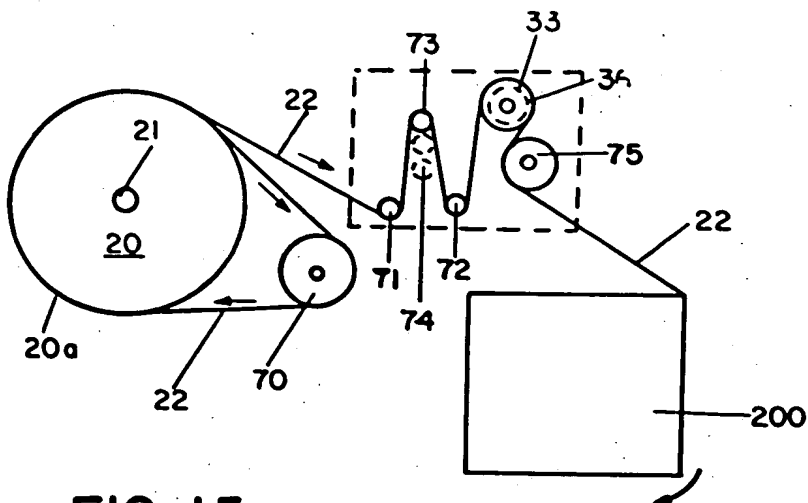


FIG. 15

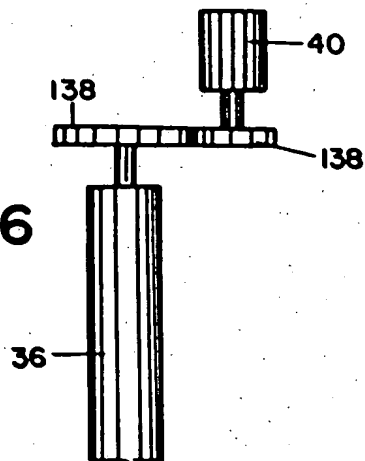
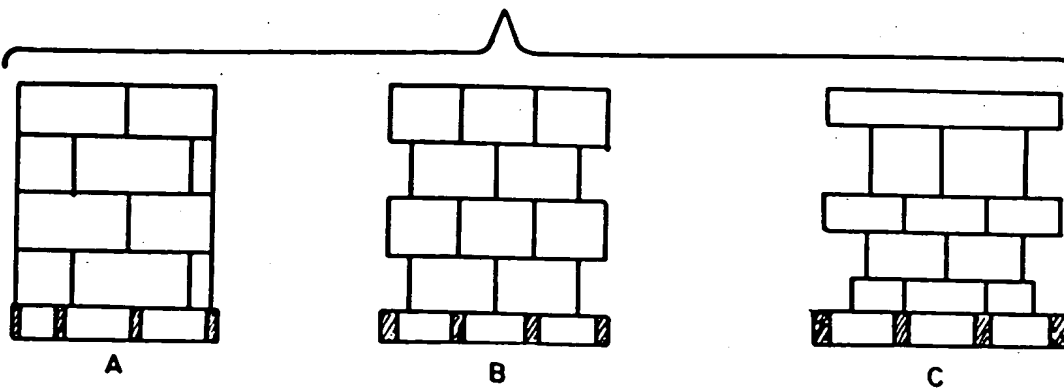


FIG. 16

FIG. 26



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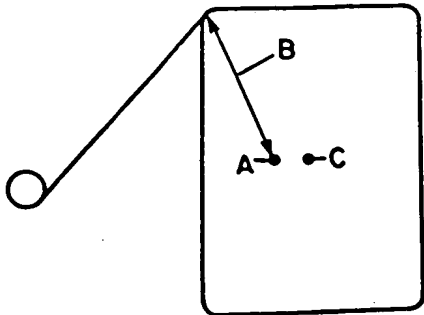


FIG. 17

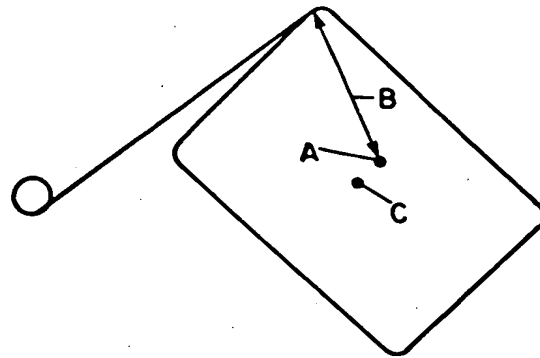


FIG. 20

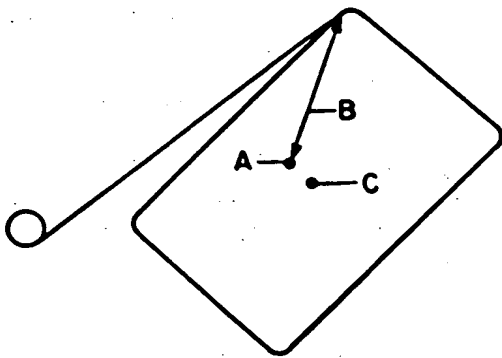


FIG. 18

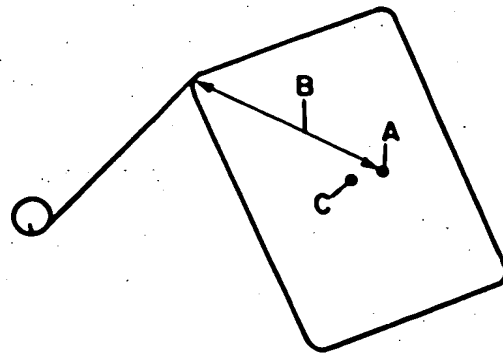


FIG. 21

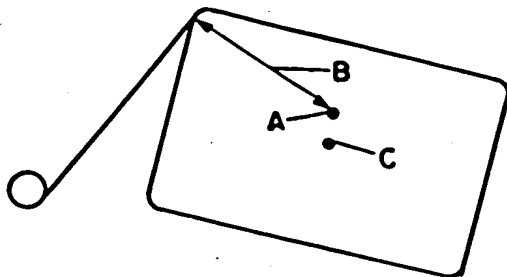


FIG. 19

FIG. 22

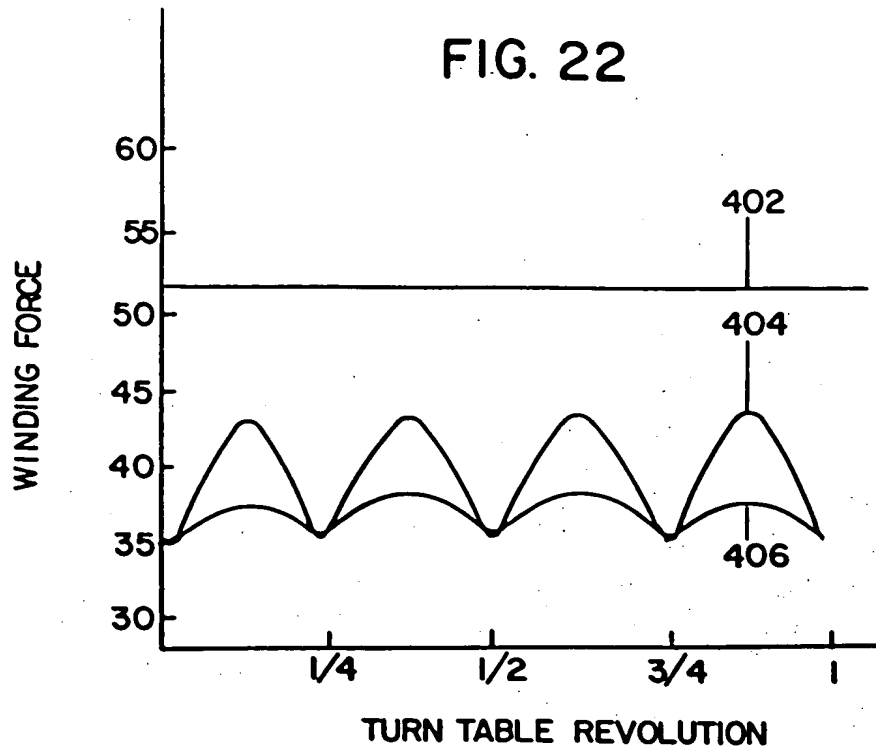
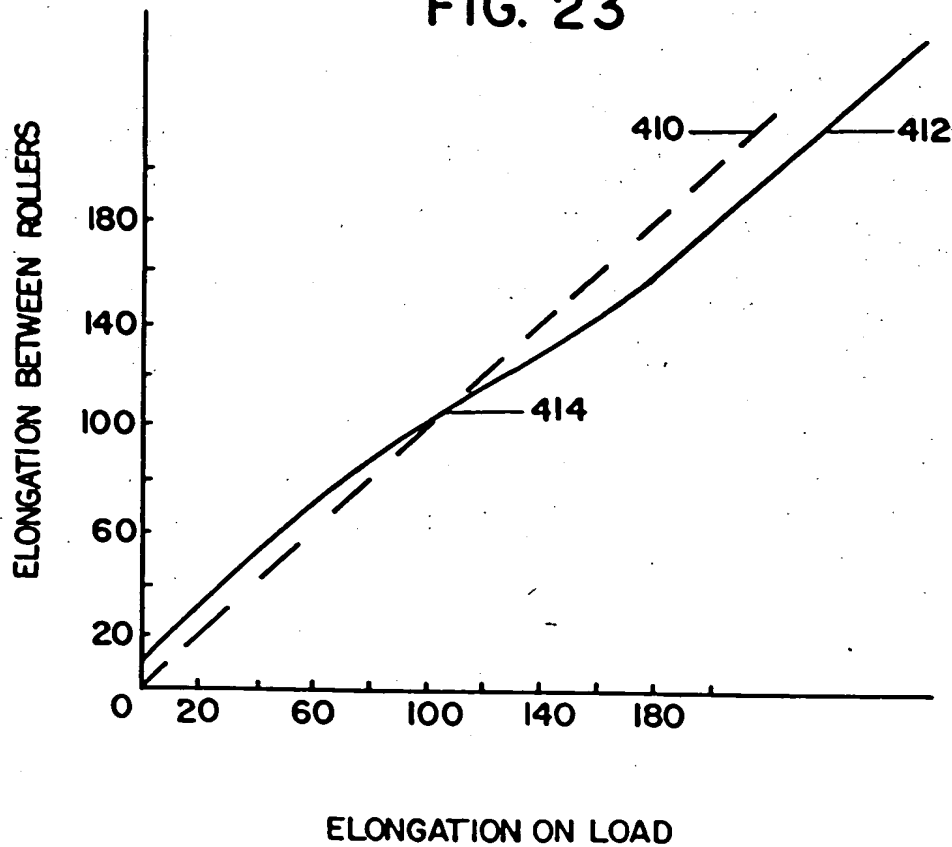
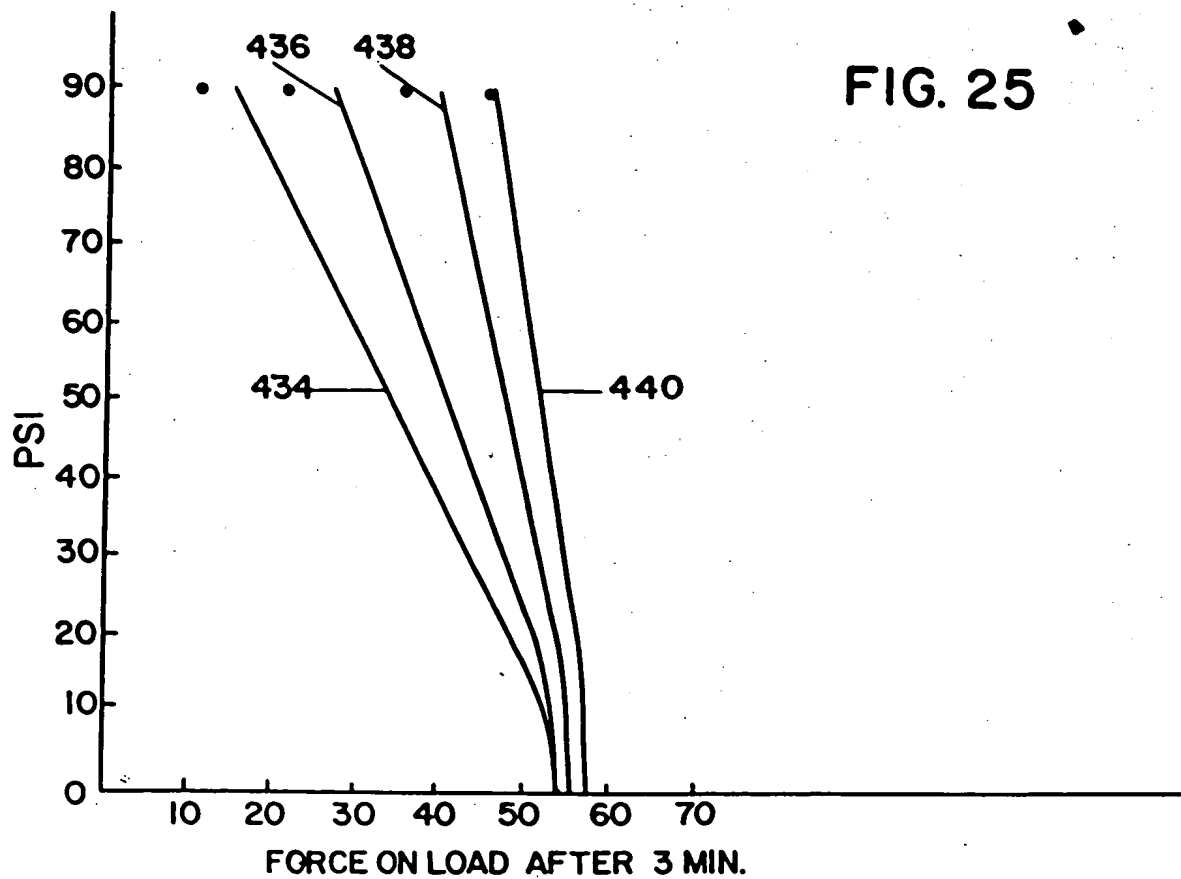
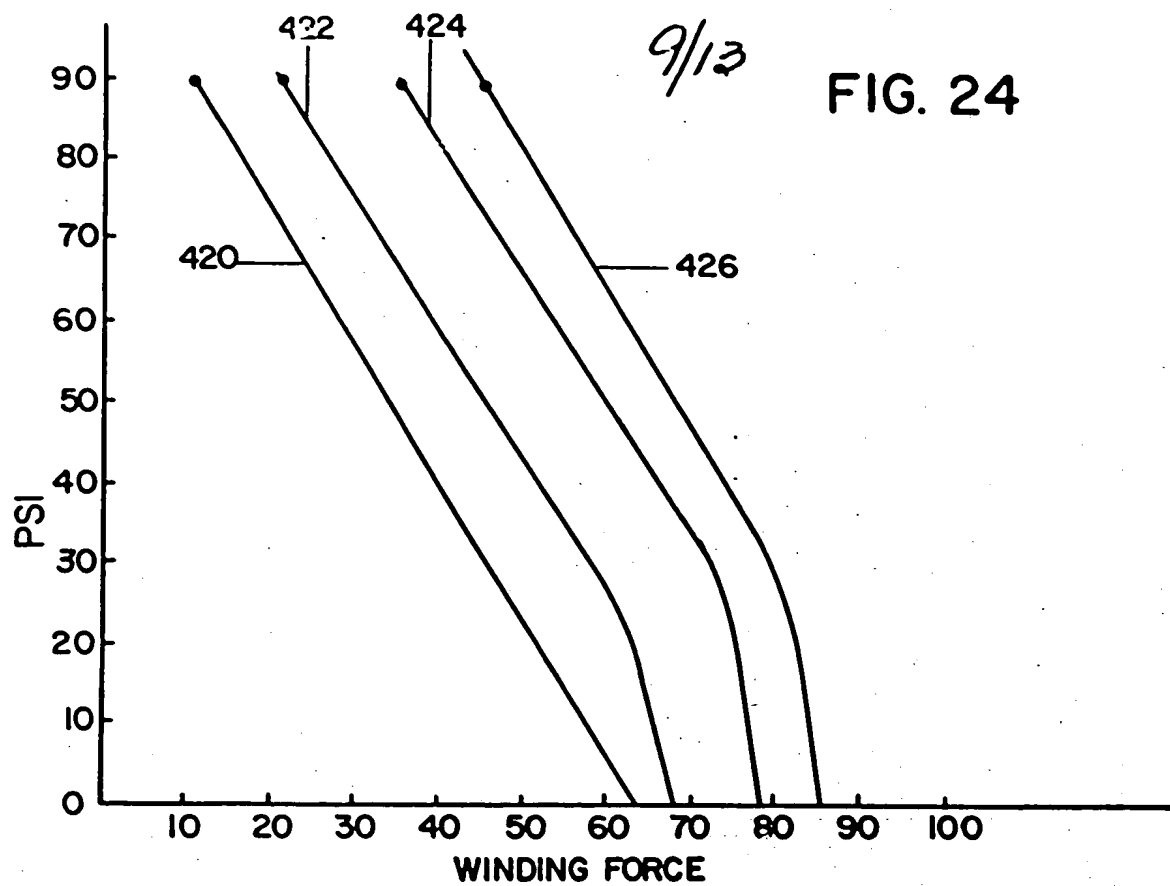


FIG. 23





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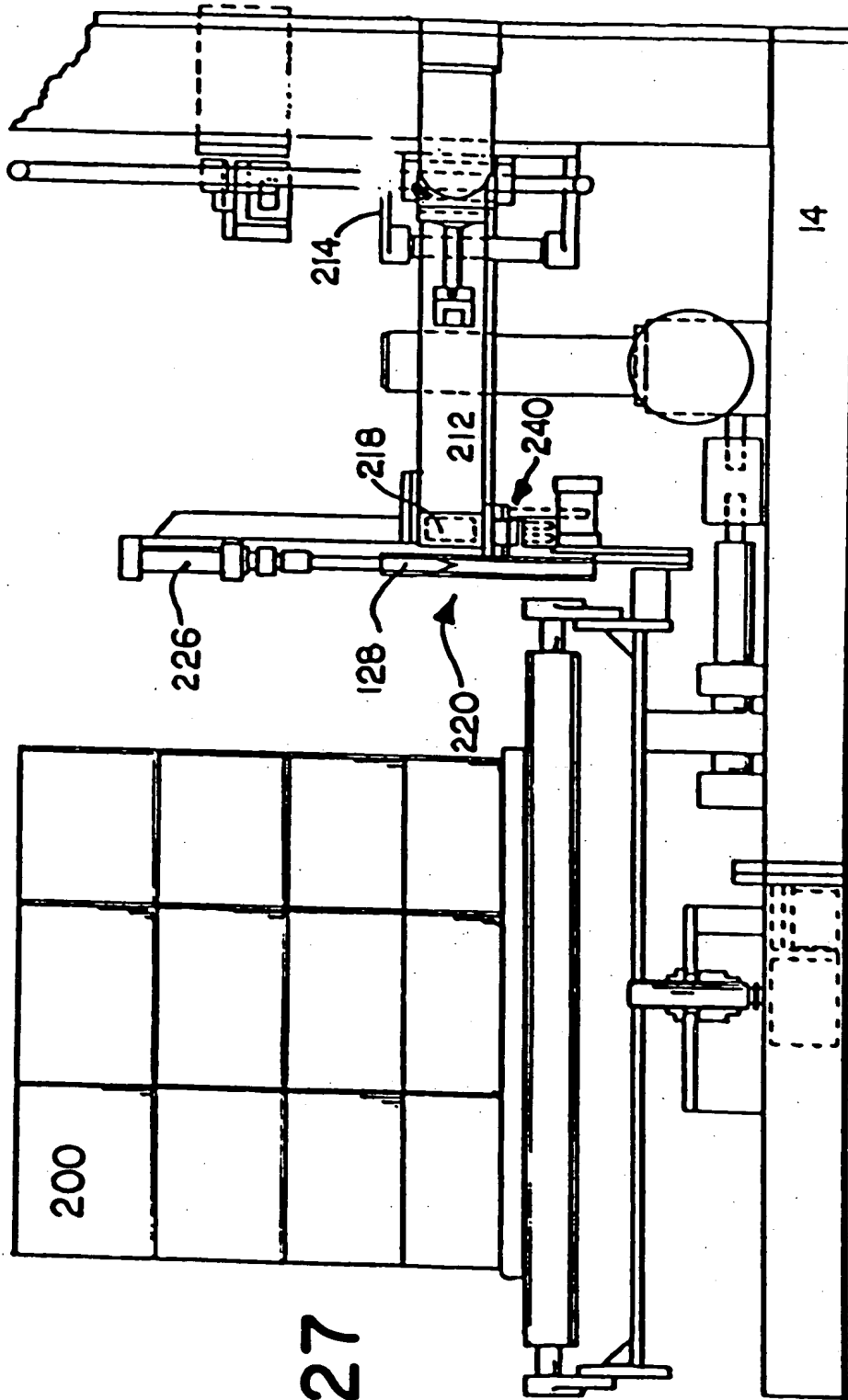
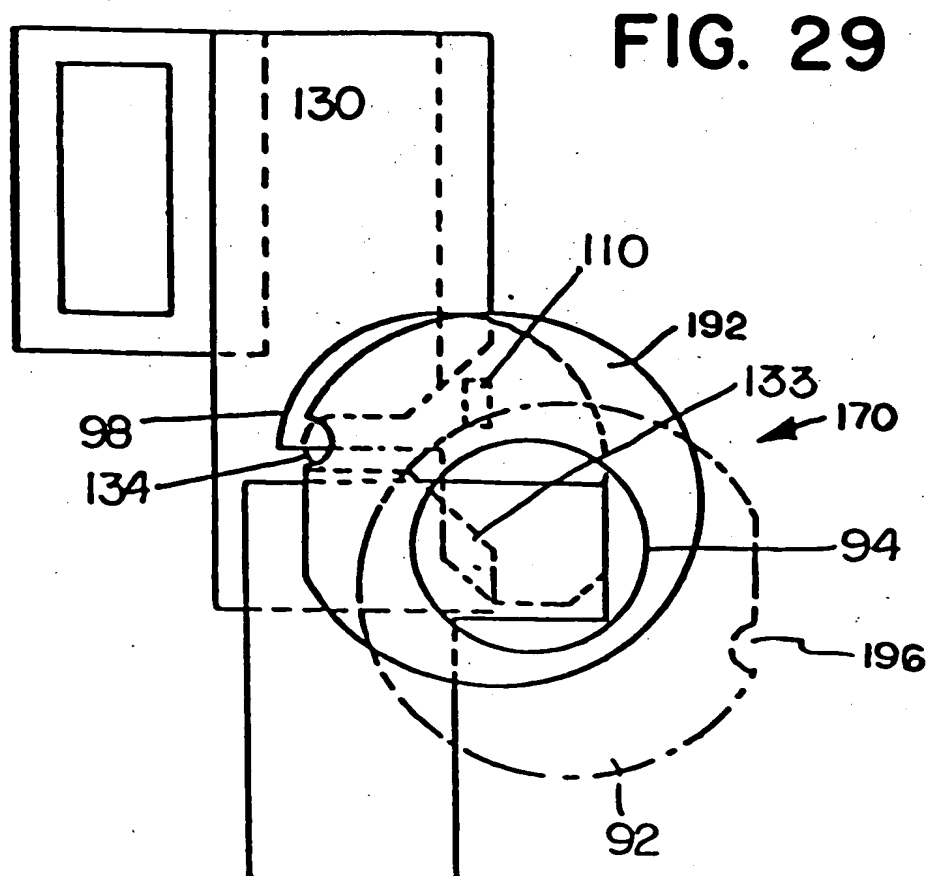
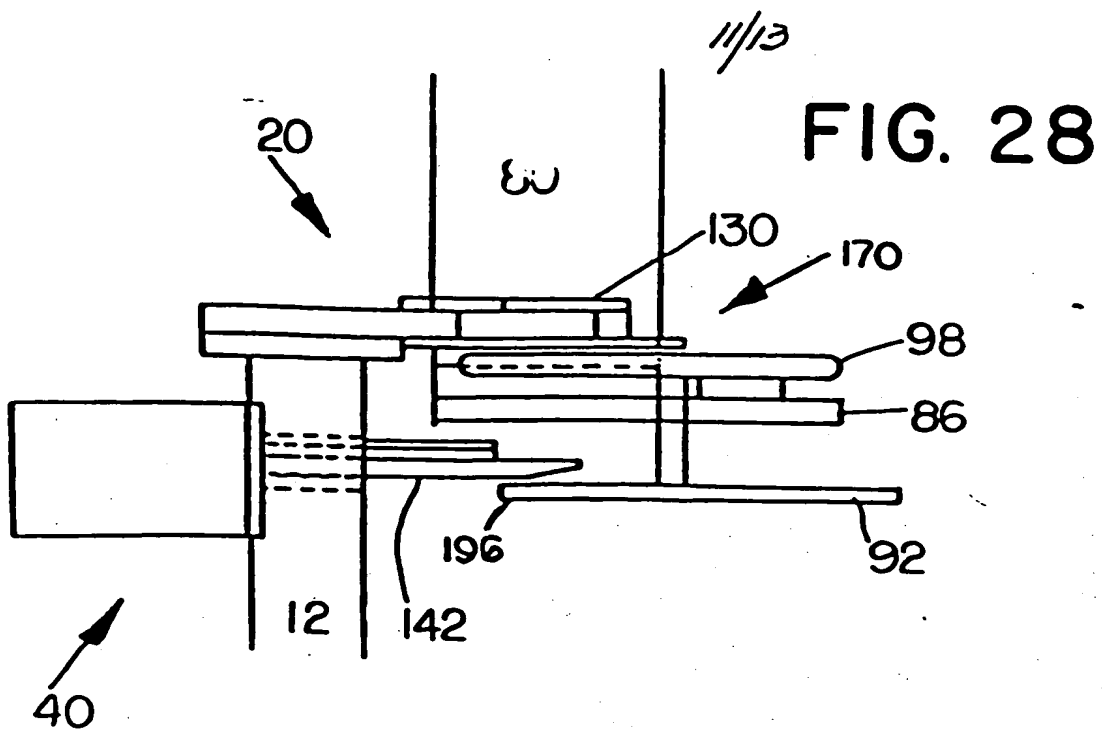
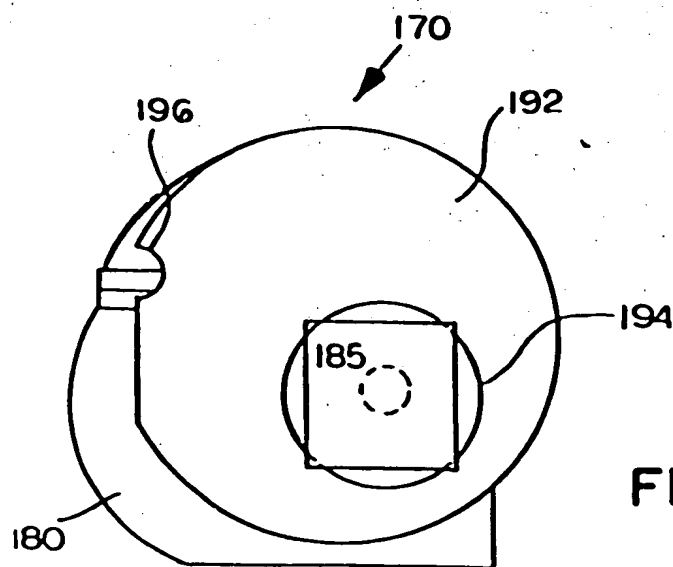
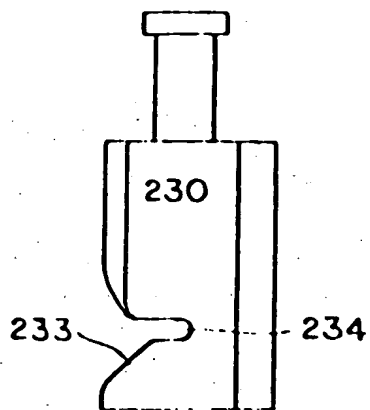
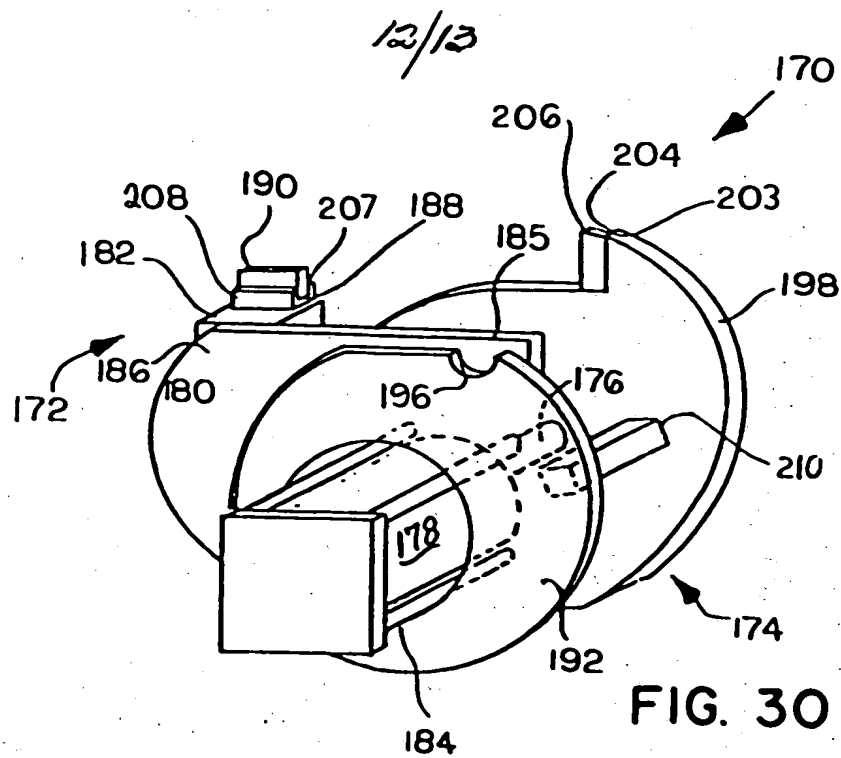


FIG. 27

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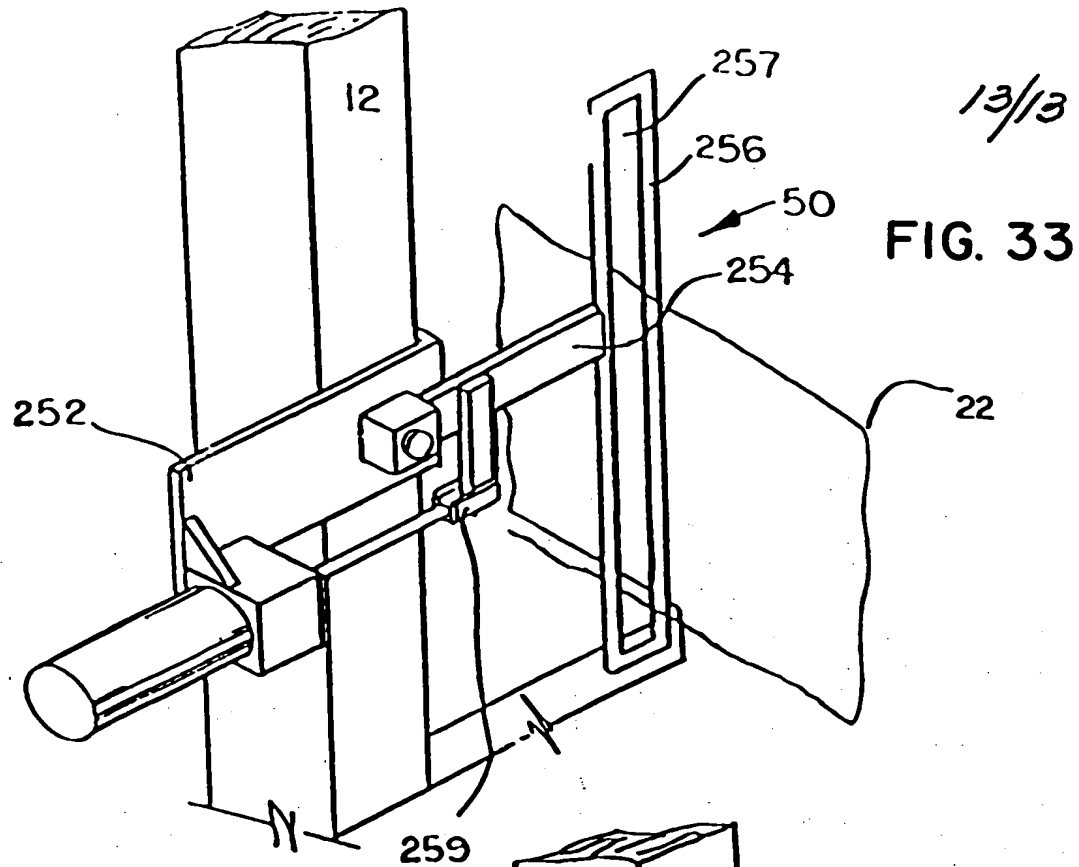
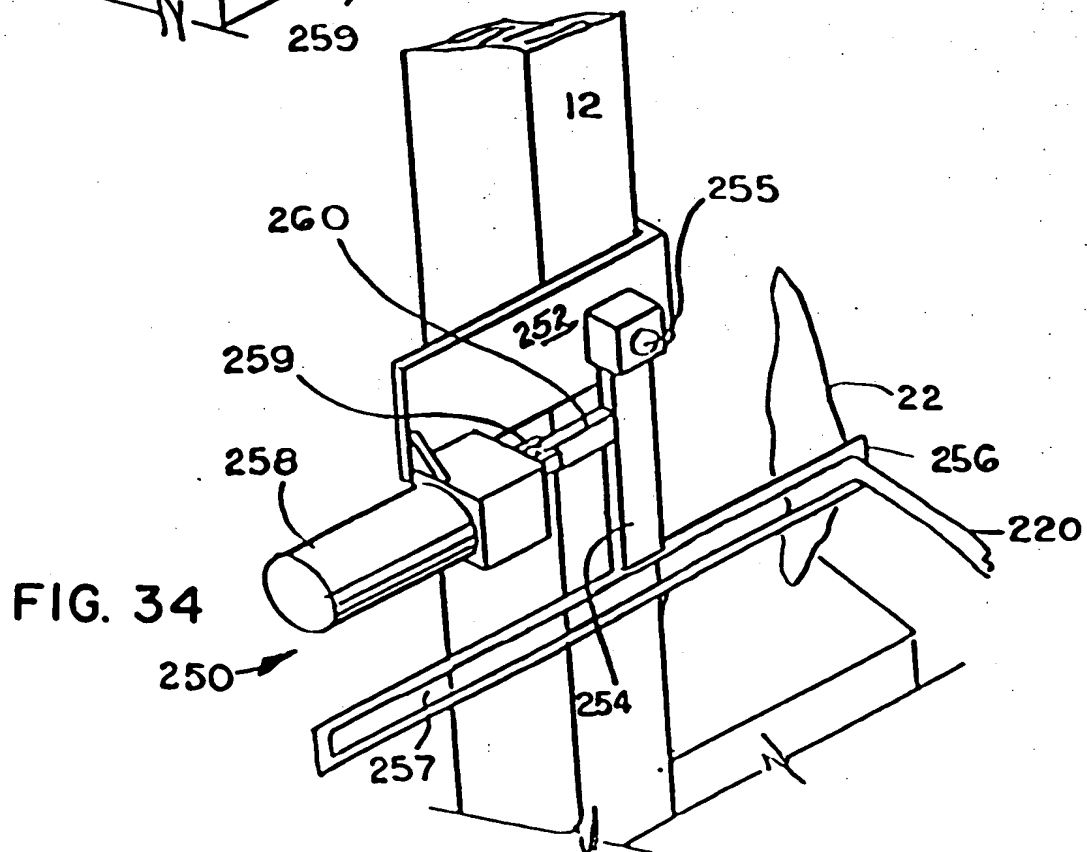


FIG. 33



SPECIFICATION

Process and Apparatus for Packaging

The present invention generally relates to packaging and more particularly to an apparatus and method for making unitary packages which hold a plurality of components, each package containing a load wrapped in a web of stretched film.

Case packing or boxing is a common way of shipping multiple unit products. The multiple unit products are generally stacked in a corrugated box or are wrapped with kraft paper with the ends of the kraft paper being glued or taped. Another way of shipping such products is by putting a sleeve or covering of heat shrinkable film around the products and shrinking the sleeve to form a unitized package. The use of heat shrinkable film is described in United States Patent Nos. 3,793,798; 3,626,645; 3,590,509; and 3,514,920. A discussion of this art is set forth in United States Patent No. 3,867,806.

Another common method of wrapping loads is with rotary stretch wrapping machines. These rotary machines are commonly referred to as spiral or full-web machines, and can operate with the load rotating to pull stretched film web around it. Alternatively, the load can be stationary and stretched film wrapped around the load with a rotating film dispenser.

A typical state-of-the-art full-web apparatus is disclosed in United States Patent No. 3,867,806.

The use of spiral wrapping machinery is well known in the art and representative machines are typified by United States Patent Nos. 3,003,297; 3,788,199; 3,683,425; and 4,136,501.

Additional references of interest which are pertinent to rotatable drives for wrapping packages are disclosed in United States Patent Nos. 3,820,451; 3,331,312; 3,324,789; 3,309,839; 3,207,060; 2,743,562; 2,630,751; 2,330,629; 2,054,603 and 2,124,770.

The film stretching means on all currently marketed pallet stretch wrapping devices employ either direct or indirect friction to restrict the film as it is being wound onto the load during the wrapping process. The restriction is either applied to the roll of film itself (direct friction) or applied to the film after it is unwound from the film roll (indirect friction). The pallet and load serve as the winding mandrel providing all of the pulling force required to elongate the film.

The earliest type of stretch wrapper utilized a direct friction device in the form of a brake that is connected to the film roll through the core as shown in Figure 1. The torque from the frictional brake device acted on the center of the film roll and as the roll changed diameter, the voltage to the brake was altered, either by the operator or automatically by a sensing device. A later film roll brake device, illustrated by United States Patent No. 4,077,179, and Figure 2 herein, utilizes a frictional brake attached to a shaft with a roller which is pressed against the freely mounted film roll. The film roll brake eliminates the need to

change the brake force during the consumption of the film roll.

Various prior art indirect friction film stretching devices have been employed to restrict the film as it is wound onto the pallet during the wrapping process. One of these devices, commonly referred to as an "S" type roller device, is shown in Figure 3, and utilizes an idle roller followed by a braked roller over which the film is threaded prior to wrapping the load. The function of the two rollers is to align the film for maximum contact with the braked roller. Another indirect friction device having fixed bars was marketed by Radiant Engineering Corporation under the trade name POS-A-TENSIONER and has been subsequently marketed by the Kaufman Company under the trade name TNT. This device, shown in Figure 4, has a series of fixed, non-rotating bars positioned adjacent to the film roll. The film web is threaded around the bars whose relative angles can be changed for ultimate tensioning. As the film web is attached to the pallet it is drawn across the bars and the friction between the film and the smooth surface of the bars provides a restriction causing the film to stretch. This device uses multiple bars with the film web stretching incrementally between each bar. Neck down of the film web increases between each bar and the load bears the force. As the load rotates, the wrap angle changes from the last bar so that the wrapping force greatly varies depending on the relative angles. The frictional restraint is determined by the vector of the film web on each bar. Thus, the device is very sensitive to the force placed on the unwind roll and the force increases as the roll size decreases adding additional force on the system. Furthermore, there must be some friction placed on the supply roll to prevent backlash. While this device solves to some degree the irregularities of the brake and the hostility of the film roll, it can only apply limited stretch to the load and does not handle different film compositions with any degree of standardization.

Another stretch wrapper device was introduced by the Anderson Company at the PMMI Show in Chicago in 1978. This device interconnected the turntable drive motor with a pair of nip rollers immediately downstream from the film unwind roll, as shown in Figure 5. The nip rollers were synchronously driven with the turntable rotation through a variable transmission which could be increased or decreased in speed relative to the turntable rotation speed. Thus the stretch on the film was affected between the constant-speed nip rollers and the pallet turning. It is not known if this machine was ever commercialized principally because of its inability to achieve satisfactory stretch over the load corners due to its failure to respond to the speed change that these corners represented. The pallet, as the film accumulating mandrel, provided the total force that was required to stretch the film from the driven nip rollers with all of the stretch occurring after the passage of the single pair of nip rollers to the pallet.

In addition to the previously noted prior art, direct friction pallet stretch wrapping machines of the pass through type have been manufactured by Weldotron and Arenco (Model N . MIPAC). These machines have a significant problem in stretching the film and normally stretch film around the load in the range of about five to ten percent. These machines depend on being able to drive the pe and associated load through a stretched curtain of film to place the stretching force on the front or sides of the load.

Since most pallet loads will not hold together while being subjected to these unequal forces, the film web is normally tensioned after the film seal jaws begin their inward travel over the end of the pallet load. This form of tensioning severely limits the degree of elongation of film which is able to be achieved and pulls excess film around the two rear corners of the load while the jaws are closing. This frequently causes film tears when the film is stretched more than ten percent.

When low stretch rates of one to ten percent are produced, several packaging problems occur. The unitizing containment forces on the load are less than the optimum force which can be obtained. This minimizing of containment forces can result in a potential loosening of the film wrap during shipment where the load settles and moves together thereby reducing the girth.

Another pass through machine described by French Patent No. 2,281,275 assigned to SAT discloses the prestretching of plastic film by taking the film web from the film roll through a powered roller system having a speed differential of $V_2 - V_1$ which stretches the film. The film leaving the second set of rollers is drawn off at a speed which is equal to or less than V_2 as it is wrapped around the load. V_1 which is the speed of rotation of the pallet load, is less than or equal to V_2 , the speed of the stretched film coming off of the second roller assembly.

Although the French Patent appears to achieve film web stretch in excess of the one to ten percent range obtained in the aforementioned pass through stretch wrapping machines, other problems remain. The system requires manual operation or complex automatic feedback to accommodate the change in film take-up speed as the pallet load surfaces pass by the downstream rollers. This reference does not teach the benefit of stretching the film above the yield point with increased strength per cross-sectional area and increase in modulus. There is furthermore no teaching of reducing the force on the portion of the film web between the downstream powered rollers and the load with inelastic strain recovery as a technique for reducing wrapping force while holding high levels of elongation.

A commercial model based on Figure 8 of the '275 reference is currently being marketed by SAT. In this embodiment the film web is pre-stretched by extending a pair of rollers forward while braking the film rolls. The load is carried into the pre-stretched "U" shaped sleeve and the

rollers are transported back of the load allowing the sleeve to engage the load. Sealer bars are then projected inward to seal the web ends together.

The aforementioned stretching devices do not maintain a consistent force in stretching the film web. These brake devices are subject to variation due to their physical construction and their sensitivity to speed change caused by passage of corners of the load and the resultant sudden speed-up and slow-down of film drawn from the feed roll.

The elasticity of the stretched plastic film hold the products of the load under more tension than either the shrink wrap or the kraft wrap, particularly with products which settle when packaged. The effectiveness of stretch plastic film in holding a load together is a function of the containment or stretch force being placed on the load and the ultimate strength of the total layered film wrap. These two functions are determined by the modulus or hardness of the film after stretch has taken place and the ultimate strength of the film after application. Containment force is currently achieved by maximizing elongation until just below a critical point where breaking of the film occurs. Virtually all stretch films on the market today including products of Mobil Chemical Company (Mobil—X, Mobil—C and Mobil—H), Borden Resinite Division PS—26, Consolidated Thermoplastics, Presto, PPD and others are consistently stretched less than thirty percent in most commercial applications despite a manufacturer's laboratory rated capacity in excess of three hundred percent in most cases.

This problem of obtaining less stretch on commercial wrapping than that available under laboratory conditions centers on several facts. A square or rectangular pallet which is typically positioned off of its center of rotation is used as the wind up mandrel for the purpose of stretching film. A typical 40" x 48" pallet positioned 3 to 4 inches off of its center of rotation will experience a speed change of up to 60% within one quarter revolution of the turntable.

In this regard, Figures 17 through 21 illustrate the manner in which constant rotation of a palletized load placed slightly off center on a turntable will result in significant variations in tension on the film web being wrapped around the load. Since the turntable rotates at a constant angular speed, the film web is drawn to and around the rotating pallet load at a speed which is determined by the distance between the axis of rotation and the point at which the web contacts the load. The axis of rotation in each of the illustrations is at point A and the distance between the axis and the film contact point is illustrated by an arrow B. The axis of rotation A is offset slightly from the true geometric axis C of the palletized load. It can thus be seen that as the load is rotated in a clockwise direction, the distance from the axis of rotation A to the film web contact point remains constant in Figures 17 through 20. However, as the load is rotated from

the position shown in Figure 20 to its position shown in Figure 21, the distance between the axis of rotation and the film contact point increases markedly, thus increasing the speed at which the film is drawn from the roller and the force between the downstream stretch roller and the pallet load.

In addition to the off centering problem most pallet loads are irregular in shape with vertical profiles which produce a significant puncture hazard to highly stretched film being wound around them. Further, some unit loads are very susceptible to crushing forces of the stretched film. Because of pallet load changes and inconsistencies within the film roll, the operator typically continues to reduce the tension settings until there are no failures. Thus the inconsistencies of films, stretching devices, and pallet loads produce an environment where very few stretch films are actually stretched to their optimum yield.

The major problems with current stretch technology are that stretch is produced by frictional force devices to restrict the film travel between two relatively hostile bodies. On the one hand the film roll is subject to edge wandering and feathering, while on the other hand the rotating pallet with its irregular edges and rapidly changing wind-up speeds severely limits the level of elongation achieved. The ultimate holding forces of the film cannot be brought to bear on the load because the film cannot be stretched enough. Even if the film could be stretched enough the high wrapping forces can disrupt or crush many unit loads. The use of high modulus films, such as oriented films, does not produce the yield benefits of the current invention, since these higher modulus films would have to be significantly stretched in order to achieve the rubberband effect and moldability required for irregular loads.

It therefore can be understood, since the pallet provides the forces for stretching the film, that stretch percentages achieved on the pallet and the stretch force achieved are intertwined in all prior art devices. As previously indicated, high stretch percentages are required to achieve the benefits of high yield but the high stretch forces incurred at these high stretch percentages cause premature film rupture and potential crushing of the load.

In an attempt to solve the aforementioned problems several other devices have been developed by the present inventors.

One device stretches the film web above its yield point between two sets of powered rollers prior to transporting the film to the pallet, increasing its modulus while reducing its cross-sectional area.

Since the film stretches between the rollers, all stretching action is isolated from the roll and the pallet. It also removes the dependence of the stretch force and elongation level. While the device can be used to wrap light or crushable loads it has several problems in actual use. The

controls necessary to compensate for the interacting speed changes are very complex and prohibitively expensive. Thus, the device generally will require feedback controls to sense force change and maintain the force level.

Another known device manufactured by Lantech Inc., under the trademark "ROLLER STRETCH" utilizes the film web to drive the apparatus. This device addresses several of the aforementioned problems. Since the film is pre-stretched between the rollers, it isolates the stretching action from between the film roll and the pallet. This device provides a consistent level of stretch and, most importantly, responds to force and speed changes without complex feedback controls as can readily be seen in the graph of Figure 22. A problem inherent with the ROLLER STRETCH (TM) device is that it has a dependence between the percentage of stretch that can be achieved and the stretch force that will be required to elongate the film. It should be noted that although these two factors are connected, the film web drive device significantly lowers the stretch force for a given elongation level, at or below the balance point as is seen by Figure 23. This is due to the mechanical advantage between the film driven rollers.

Balance is achieved when elongation between the rollers (E_1) is equal to elongation on the load (E_2). The relatively higher forces between the closely spaced rollers are overcome by the lower force required to drive the device by the film between the roll and the load. The stress/strain curve experienced between closely spaced rollers is substantially higher than the curve where film is allowed to expend the pulling force. Thus, the film to the load affects this higher force between the rollers aided by the mechanical advantage of the differential pulley relationship of the gear connected rollers. At balance point 414 the elongation on the load (E_2) equals elongation between the rollers (E_1) and the mechanical advantage represents the differences between the forces corrected for friction. This limits the film drive device to an elongation level on most films of under 120 percent elongation between the rollers.

It is therefore apparent that there exists a need for a pallet load wrapping apparatus which reduces or eliminates the dependence between the percentage of stretch that can be achieved and the force that will be required to drive the pre-stretch device.

According to one embodiment of the present invention there is provided a process of making a unitary package by wrapping a plurality of units with a stretched plastic material overwrap forming a unitary load comprising the steps of:

- a. transporting a web of plastic film to a stretching means;
- b. elongating the film in the stretching means over its yield point, thereby gaining substantially in strength per cross-sectional area and modulus;
- c. acting upon said elongated material with a

force relieving means while wrapping said load;
and

- d. relieving the force on the film web wrapped around the load by transmitting the speed changes of the load surface through the film web to relieving means to selectively speed up and slow down the film web keeping a relatively constant force and stretch level on the load.

According to another embodiment of the invention there is provided an apparatus for making a unitary package from a plurality of units forming a load using a web of stretchable plastic material to form the overwrap comprising a frame, plastic material dispensing means mounted to said frame, means to pull said plastic material from said material dispensing means, material elongation means positioned between said dispensing means and said load, said material elongation means being adapted to receive plastic material pulled from said dispenser means and elongate the stretchable plastic material beyond its yield point, and means to reduce the stretch force of the material on the load, to a level equal to or less than the force required to stretch the material web.

In the present invention the film web is stretched prior to wrapping the web about the load. In a preferred embodiment the film passes between rollers in the stretching assembly configured for optimum film surface friction to avoid slippage. The rollers are interconnected by a gear or other speed ratio means, so that the wrapping of the film around the load will drive a downstream roller interconnected to an upstream roller at a ratio pre-selected for optimum stretch of the particular film composition. The entire roller means may be mounted for movement along a horizontal axis so that the upstream roller can be urged against the film roller to interconnect the upstream roller by friction thus avoiding backlash while maintaining very low friction on the unwind shaft. A positive torque means is connected by a spur gear or other means to the downstream roller to provide some portion of the force that is required to operate the stretching assembly. Thus, the force placed on the film web between the downstream roller and the pallet can be reduced to the optimum level. Since it is the interconnection by the film to the turntable which is driving the stretching assembly, speed changes on the load surfaces are transmitted back to the upstream roller, speeding up and slowing down the rollers as necessary in order to keep a relatively constant force and stretch level.

Film elongation may be achieved in the present invention, in excess of three hundred percent offering significant economies in film costs during operation, without damage to delicate loads and the destructive uneven stresses on the film web which are recognized as prevalent deficiencies in the prior art. High elongation levels have been found to significantly increase ultimate film strength when elongation occurs between closely spaced rollers where neck down can be virtually eliminated. Tests have indicated that ultimate

strength of Mobil—X and Bemis ST—80 increases over twenty percent after having been elongated one hundred and forty percent between two rollers spaced one half inch apart. This strength increase is in addition to the increase in strength per cross-sectional area. Thus, the invention provides for a consistent force wrap with a higher wrap yield per pound of plastic. The wrap has a high resistance to load shift with low neck down during wrapping and no stress relaxation of the wrap on many films. The invention has the ability to wrap light or crushable loads and irregular loads which may require additional reduction of the wrapping force.

The present invention will now be further apparent when read in conjunction with the following detailed description of the preferred embodiment of the invention.

Brief Description of the Drawings

Figure 1 is a side elevational view of a prior art core braking mechanism engaged with a film supply roll;

Figure 2 is an isolated side elevational view of prior art roller braking mechanism engaged with a film supply roll;

Figure 3 is an isolated top plan view of an "S" configuration prior art stretch wrapping apparatus;

Figure 4 is an isolated top plan view of friction bar prior art stretch wrapping apparatus;

Figure 5 is an isolated top plan view of a turntable driven nip roller prior art stretch wrapping apparatus;

Figure 6 is a side elevational view of the preferred embodiment of the present inventive apparatus;

Figure 7 is a top plan view of the apparatus shown in Figure 6;

Figure 8 is an isolated front elevational view with turntable removed of the apparatus of Figure 6;

Figure 9 is an enlarged isolated side elevational view of the film stretching assembly of the invention;

Figure 10 is a front elevational view of the film stretching assembly shown in Figure 9;

Figure 11 is a top plan view of the film stretching assembly shown in Figure 9;

Figure 12 is an isolated partial front elevational view with casing removed of the film stretching assembly of the present invention;

Figure 13 is an isolated schematic top plan view of the inventive apparatus including the film web and load;

Figure 14 is an isolated perspective view of the apparatus in Figure 13;

Figure 15 shows a top plan view of an alternate embodiment which can be used in the present invention;

Figure 16 is an isolated side elevational view of the constant torque device and rollers used in Figure 13;

Figure 17 is an isolated top plan view of a

palletized load at the beginning of the wrap cycle in a stretch wrapping apparatus;

Figure 18 shows the palletized load of Figure 17 rotated through an angle of 45 degrees;

5 Figure 19 shows the palletized load of Figure 17 rotated through an angle of 100 degrees;

Figure 20 shows the palletized load of Figure 17 rotated through an angle of 135 degrees;

10 Figure 21 shows the palletized load of Figure 17 rotated through an angle of 160 degrees;

Figure 22 is a graph of winding force versus angular turntable rotation for the present invention and other embodiments;

15 Figure 23 is a graph of the balance point of elongation between rollers and elongation in the ROLLER STRETCH (TM) embodiment;

20 Figure 24 is a graph of the torque provided by the constant torque device of the invention versus the winding force exerted by the load for a variety of roller speed ratios;

Figure 25 is a graph of the torque provided by the constant torque device of the invention versus the force on the load after three minutes for a variety of roller speed ratios;

25 Figure 26 is a front elevational view of a composite of three loads types A, B and C;

Figure 27 is a partial side elevational view of a roping and tying assembly used with the invention;

30 Figure 28 is an enlarged partial top plan view partially in section of the clamping assembly and tying assembly of Figure 27;

35 Figure 29 is a side elevational view of the clamping assembly shown in Figure 28 showing the position of the clamping assembly when rotated in phantom;

Figure 30 is an enlarged isolated perspective view of the clamping assembly of the roping mechanism in an open position;

40 Figure 31 is a side elevational view of the clamping assembly of Figure 29;

Figure 32 is a side elevational view of the cutter mechanism housing;

45 Figure 33 is a partial perspective view of the roping mechanism of the apparatus when the web is in a full width open position; and

Figure 34 is a partial perspective view of the roping mechanism when the mechanism is rotated to collapse the web into a rope.

50 Detailed Description of the Drawings

The inventive wrapping apparatus 10 is shown in Figures 6 through 34, with the preferred embodiment and best mode of the invention being shown in Figures 6 through 14. The operation and description of the apparatus and its respective component parts is discussed in the following description.

60 The film web driven stretch wrapping apparatus 10 comprises an upright frame 12 sitting on a base 14. In the preferred embodiment and best mode of the invention, a carriage 16 is movably mounted on the frame 12 by means of rollers 13 rotatably mounted on tracks 15 secured to the frame. The carriage has a motor 17

65 mounted on it to provide the power for a rack and pinion drive 19. However, chain or other suitable drive means can be used. These drive means are well known in the art and are typified by machine Model Nos. SVS—80, SVSM—80, STVS—80, 70 STVSM—80 and SAHS—80 manufactured by Lantech Inc. The apparatus 10 may also be a full-web apparatus with the carriage removed as is well known in the art. Such machines are typified by machine Model Nos S—65, SV—65 and 75 SAH—70 manufactured by Lantech Inc. A typical state-of-the-art full-web machine is also disclosed in United States Patent No. 3,867,806.

A film unwind stand 18 which is well known in the art is mounted on the carriage 16 or base 14 80 in the case of a full-web machine. The stand is constructed with sufficient drag to allow smooth film to unwind without backlashing from film roll 20 to a first roller 34 which is mechanically connected by a gear assembly 50 to a second 85 roller 36. The rollers 34 and 36 are closely spaced together preferably in the range of 1/4 inch to 2 inches, geared for reverse rotation, and are rubber faced for maximum film contact. This close 90 relationship of the rollers prevents significant neckdown of the film with the stress/strain curve on the film being substantially higher than the curve where film is allowed to freely neck down during stretching. As is seen in Figures 9 through 11, the rollers are connected by a gear assembly 95 50, but it should be noted that they could alternatively be connected by chains, belts or other mechanism (not shown). Since most films, except linear low density polyethylene, reach their yield point before thirty percent elongation, the gear speed relationship should be variable from 100 thirty percent to three hundred percent to allow use on all stretch films which are currently available in the marketplace.

EVA copolymer films of high EVA content such 105 as the film manufactured by Consolidated Thermoplastics "RS—50", and PPD "Stay-Tight" are preferably pre-stretched from one hundred thirty percent. PVC films such as Borden Resinite "PS—26" are best pre-stretched at levels of forty 110 percent. Premium films such as Mobil—X, Presto SG—4, Bemis ST—80 and St. Regis utilize a new low pressure polymerization process resin manufactured by Union Carbide and Dow Chemical Company. This resin, called linear low 115 density polyethylene, has significantly different stretch characteristics than previous stretch films. These characteristics allow the film to withstand the high stress of over two hundred fifty percent elongation during pre-stretch without tearing 120 during wrapping of the pallet. In the preferred embodiment of the invention, as shown in Figures 6 through 14, rollers 34 and 36 are respectively secured to rotatable shafts 35 and 37 which are in turn mounted in respective journals 125 33 mounted to the gear housing 52 and carriage 16.

A gear 38 is mounted on shaft 35 and is rotated by the film web 22 driving roller 34. A clutch assembly 44 is also mounted to shaft 35.

The clutch assembly is an over-the-counter Warner friction brake PC—500. A clutch plate 46 is mounted to the end of shaft portion 35" opposite the face of the clutch member 48

5 secured to the end of shaft portion 35'. When the clutch is operative, pins (not shown) interconnect the clutch plate 46 with the gear 38 engaging the gear member 38 so that it rotates simultaneously with roller 34. When the clutch is not operative or energized, the roller 34 freewheels or turns without relationship to gear 38 thus allowing a film web to be easily threaded through the roller assembly and attached to the load. The use of such clutching mechanisms is well known in the art. Gear 38 is adapted to engage and mesh with an opposing gear 138 mounted on shaft 37. The interconnection of the gears is such that haul off of the film web by the load will drive the downstream gear 138 through interconnected rollers 34 and 36 at a pre-selected ratio for the optimum stretch for the particular film used.

The entire roller assembly 55 can be mounted for movement on a horizontal axis so that the upstream roller 34 can be urged against the film roll to engage the upstream roller by friction to the roll unwind to avoid backlash while maintaining very low friction on the unwind shaft.

Opposing gear 138 is further adapted to engage and mesh with a spur gear 238. The spur gear 238 is mounted to a shaft 39 of a standard gear reduction assembly 41 which is connected to an air powered positive torque device 40. The positive torque device 40 when powered by a selected air pressure drives the downstream gear 138 through spur gear 238 to reduce the forces on the film web while the film is being stretched. The interconnection of the positive torque device 40 provides a portion of the force that is required to rotate rollers 34 and 36 and their associated gears 38 and 138. Thus the force placed on the film, between the stretching assembly and the pallet can be reduced to an optimum level. The winding force required on the part of the rotating pallet is less than it otherwise would be. The function of the torque device 40 is therefore analogous to power steering in an automobile. Thus the effort required on the part of the rotating pallet is less than it otherwise would be. Preferably the force between the rollers 34 and 36 is greater than that between the downstream roller 36 and load 200. Since the positive torque device 40 drives gear 138 by adding a constant torque rather than a constant angular rate, speed changes on the haul off of the film will be transmitted back to the rollers 34 and 36 increasing and decreasing speed in response to the changing effective diameter of the load 200 as previously discussed and shown by Figures 17 through 21, thus keeping a relatively constant force and stretch level. The constant torque device 40 will allow balance to be achieved at higher film elongation levels than that of the ROLLER STRETCH (TM) device which is only driven by the turntable rotated pallet load interconnected to the film web. At the point when

the mechanical advantage will not overcome the difference in force between the amount to stretch the film between the rollers and that amount to hold the elongation to the load, the constant torque device becomes essential. The film Mobil—X reaches this balance point at 110% (see Figure 23) with the ROLLER-STRETCH (TM) embodiment. Higher gear selections produce secondary stretch without torque assistance. Up to and above 250% gear selections are possible with torque assistance to overcome the higher stretch forces between the rollers. Thus, the torque assist must make up for the loss in mechanical advantage as the gear ratio is increased for higher elongation on the load. It can be seen that power assisted roller-stretch has all the advantages of power-stretch but does not require the feedback controls and has all the advantages of ROLLER-STRETCH (TM), plus the ability to significantly increase the level of the film elongation on the load and establish a force (f_2) independent of f_1 or E_1 .

In a working embodiment of the invention, commercial over-the-counter air motor model nos. 1AM—NRV—56—G and 1AM—NRV—60—GR11 with a 15:1 gear reducer manufactured by Gast Co. have been used as the constant positive torque device 40. However, it should be noted that other known conventional constant positive torque devices powered by electricity or other positive torque devices may be used with satisfactory results.

In operation of the preferred embodiment as shown schematically in Figure 13, the film web 22 is pulled from the film roll 20, threaded around the two rollers 34 and 36 which are configured for optimum film surface friction to avoid slippage and then secured to the load 200 by attachment to a clamp 60 mounted to the turntable as shown in Figure 6, or by tucking the leading end of the film web into the load. A release system such as clutch assembly 44 shown in Figures 9 through 12 can be used to ease the tucking or start up for the full-web or high modulus film applications. If desired, the turntable revolution can begin with the turntable clutch disengaged. After passage of at least one corner of the load, the clutch is engaged to connect the gears and rollers to each other at the predetermined gear ratio. Typical gear selections which have been used with the following films are: Mobil—X 250 percent; EVA 150 percent; and LDPE 70 percent. As the turntable 202 rotates, the film web 22 is pulled across the first roller 34 thereby precisely increasing the speed for the second roller 36 to a predetermined ratio controlled by the gear assembly. The connection means can be a gear transmission or any other conventional speed ratio linkage system. The film is thereby precisely elongated by a percentage represented by the relative speed differential of the rollers.

Simultaneously to the engagement of the clutch the air pressure is connected to the air torque device to assist the roller assembly in stretching the film web to the level represented by

the gear ratio reducing the stretch force. The torque assist must make up for the loss in mechanical advantage as the gear ratio is increased for higher elongation on the load.

5 Alternately, the clutch could remain engaged or be eliminated and the torque device could be pressurized upon the turntable start to relieve pressure on the tuck or clamp.

10 Before wrapping the load, the air pressure to the powered torque device 40 is set to the desired stretch force, namely a force which does not crush the load or distort it during the wrapping operation, up to the balance point. Typical psi of air pressure to device 40 to assist the film

15 Mobil—X on a very regular load type A is 40 psi, a slightly irregular load type B is 60 psi and a very random and irregular load type C is 80 psi. A spiral or full-web wrap cycle is accomplished on the load in a manner known in the art.

20 Approximately one quarter turn before completion of the last turntable revolution the clutch can be partially or completely disengaged to allow unwinding of selectively less stretch film to get it into a take-up range allowing it to be wiped on a wrap. Air pressure to the torque device is significantly reduced at the same time. This step is undertaken when a film is used which loses its tackiness when it is stretched past the yield point. One such film that behaves in this manner is

30 Mobil—X. Cutting and sealing is performed in a standard known manner. Other films do not lose this tackiness property and can be wiped onto the load or tied to the load as is described in the specification.

35 One positive aspect of the inventive wrap is that the very rapid elongation of the film followed by rapid strain relief of certain films will cause a "memorization" effect. Generally, films when stretched above the yield point with the stretch force from the stretching assembly to the load reduced at least fifty percent from that force achieved within the stretching mechanism and wrapped on the load at more than 100 linear feet per minute with a dwell time between the stretching assembly and the load of less than one half second achieve significant memory. Due to this memory effect, the film will significantly increase holding force and conformation to the load. PVC films, such as PS—26 by Borden

50 Resinite Division, demonstrate this memory capacity very significantly. As an example, a 20 inch web of Mobil—X, stretched at 250 percent and power assisted down to thirteen pounds of force, when wrapped on the load shows an

55 increase in force over three minutes. This is the reverse of stress relaxation of over 20 percent in the first three minutes when stretched conventionally. Because of the film's memory, the film will actually continue to shrink for some time

60 after being subjected to the high levels of stretch above the yield point and immediate reduction of force. This film characteristic as shown in graph form in Figure 25 as compared to Figure 24 can be used to wrap loads at very close to zero stretch

65 wrapping force using the memory to build stretch

force and load conformity. As can be noted from both graphs, when film has been assisted by 80 to 90 psi there is a substantial increase in force after three minutes as can be readily seen from the top points of the curves.

70 The air system positive torque device was selected because of its very low inertial mass, low weight and responsiveness to speed change without torque change. Optimum wrapping results and machine reliability were obtained while keeping the film elongation on the pallet in balance or equal to or less than the elongation incurred between the rollers. At elongations significantly above elongations achieved between the rollers, secondary stretch occurs between the stretching device and the load. This secondary stretch induces significant forces in the film which cause premature zippering of the film on any load irregularity. Furthermore, this secondary stretch

85 increases neck down of the film.

When film loses its tackiness after being stretched beyond the yield point or in other wrapping circumstances, it may be desired to rope and/or tie the film web to complete the package wrap. In such circumstances the unit load is either spiral or full-web wrapped in a conventional manner. Preferably, the film web is roped upstream of the roller system as is shown in Figures 33 and 34. However, for certain

90 applications the film web can be roped downstream of the roller system. The roping mechanism 250 comprises a support plate 252 secured to frame 12, and a rotatable support bar 254 having one end rotatably mounted to the support plate, the other end being secured to the web reduction member 256. The web reduction member 256 comprises a rectangular shaped bar which defines a rectangular aperture 257. The length of the rectangular aperture is greater than the width of the web of material used for wrapping the load and the thickness of the rectangular aperture is greater than the thickness of the web. Preferably, it is also equal to the desired thickness of the web when the edges are

100 roped so that when member 256 is rotated, web material 22 is roped into a width substantially equal to the width of aperture 257 as shown in Figure 34.

A pneumatically activated cylinder 258 is

115 secured to the support plate 252 or the frame and has an end 259 of its piston rod rotatably connected to drive bar 260 which is in turn secured to the rotatable support bar 254. Cylinders 258 can be energized by known fluid circuitry to move the rotatable support bar so that it rotates around the pivot point carrying the web reduction member 256 upward or downward in an approximate 90° arc. This causes the web material to be formed into a roped configuration

120 500 when the rectangular member is parallel to the ground or alternately all webs flow through the open web through the web reduction member 256 when the web reduction member is positioned substantially perpendicular to ground.

125 The material web when roped passes through

130

a clamping assembly 170 mounted to the edge of the turntable. It should be noted that turntable clamp 60 is not present when web roping is used.

The clamp assembly 170 comprises a stationary arm mechanism 172 and a rotatably mounted clamp mechanism 174 mounted to a shaft 175 which is rotated by a rotary pneumatic cylinder 178.

The stationary arm mechanism 172 comprises a support block 180 mounted to turntable 308, a seat support 182 secured to the support block 180 and a cylinder support subassembly 184 secured to the support block. The support block has its rear portion 185 secured to the pneumatic cylinder and its forward portion 186 secured to the stationary seat support 182. The seat support 182 has a U-shaped seat 188 with a resilient friction member 190 made of rubber or other suitable resilient material secured in the seat and extending above the legs 207 and 208 of the U-shaped seat 182 for engagement with clamp arm 198 of the rotary clamp mechanism 174. The rotary clamp mechanism 174 comprises a material guide member 192 of an eccentric shape having a circular aperture 194 of suitable diameter surrounding the pneumatic cylinder 178 so that the guide member 192 can freely rotate around the pneumatic cylinder. A curved surface notch 196 is cut inward from the exterior edge of the material guide member 192 a suitable distance which allows the notch to receive and guide the roped material during the tying and severing operation of the apparatus.

The clamp arm 198 is secured to the spacer bar 210 which is secured in turn to the guide member 192. The clamp arm 198 has a cut-away segment 203 which approximates a curved L-shaped surface forming the contact surface for engagement with the resilient member 190. The segment 202 has a planar surface 204 adapted to engage the resilient friction member 190 to hold the roped material therebetween. The outwardly extending leg 206 of the L is adapted to be positioned adjacent the leg 208 of the seat 188 to engage the stretched material at the smallest angle of extension from the wrapped package.

A cutting mechanism 220 and tying mechanism 240 are secured to a moveable arm 212 which sequentially moves the mechanisms into the path of the material for the severing and tying steps. The arm 212 is rotatably mounted on support structure 214 and is driven by pneumatic cylinder 216 secured to the frame 222. Extension of the piston arm 217 of cylinder 216 drives the arm and the associated cutting and tying mechanism into the material path so that the mechanism can perform its desired function.

Secured to the traversing arm 212 are a perpendicularly extending arm 218 which holds the tying mechanism 240 and a support structure 219 which is mounted to the top of the arm and supports the cutting mechanism 220. The cutting mechanism 220 comprises an upright support plate 222 and traverse brace 224 secured to the support plate and a piston 226 which is secured

to the upright support plate 222. A piston arm 227 extends from the piston, the distal end of which is secured to a cutting blade 228. The cutting blade 228 is reciprocally positioned in a guillotine sheath or housing 230, which is secured to the end of the traversing arm 212. The guillotine sheath 230 comprises a plate structure having an inwardly inclined notch 233 cut into one side adapted to receive the roped material and direct it into a center of the notch 234. The trailing end of the roped material is held and carried in cutting notch 234 to a point where it is positioned beside the leading roped end of the wrap held in guide member notch 196 so that both the leading and trailing roped sections of the wrap are severed by reciprocating action of the cutting blade 228.

A standard hog ringer device 242 such as that made by ATRO Company, Types I and C, is secured to the lower part of arm 219. A magazine 244 extends perpendicularly from the mechanism to feed staples or hog rings into the mechanism. In operation of this standard hog ringer, the shaped nose of the hog ring engages the leading and trailing ends of the roped material to be tied together and a ring or staple is driven around the roped material held in the nose of the ring and fastened around the roped sections by bending the ring or staple around the roped sections to be tied. Thus, the two roped web layers which have been placed side by side are fastened together through the action of the hog ring passing a staple around both of the ropes and fastening or tying them together through the contraction or bending of the staple or ring around the materials.

An alternate embodiment of the invention is shown in Figures 15 and 16. In this embodiment of the invention a film roll 20 is mounted on a mandrel 21 and the film web 22 is withdrawn from the film roll around an idle roller 70 and back around a rear section 20(a) of the outside circumference of the film roll 20 to act as a brake on the film roll keeping the film roll from free wheeling. The web 22 is threaded around fixed bars 71, 72 and 73 so that the film web will be stretched by the frictional engagement of the web on the bar surfaces as the web is pulled over the bars by the palletized load. It should be noted that the bar 73 can be moved to any one of a number of different positions 74 to change the angle of the film web on the fixed bars thus imparting different degrees of stretch to the film. When the film web leaves the downstream bar 72 it is passed around a power assisted roller 36 which is driven by a spur gear 138 of torque device 40 and around an idle roller 75 onto load 200. A turntable clamp assembly 60 holds the leading end of the film web for the initial part of the wrap. Preferably, the entire apparatus is mounted on a movable carriage for spiral or full web wrapping but it is envisioned that elongation system could be separated from the carriage in certain circumstances. Thus, the alternate embodiment utilizes the powered constant torque device 40 to reduce the force from that which is imposed on

the film by bars 71, 72 and 73 to that which is placed on the load. It is apparent that the constant torque device can be utilized between any film stretching assembly if it is positioned downstream of that assembly between the assembly and the load to reduce the force on the film web being applied on the load.

Thus, it can be seen that the process and apparatus for elongating plastic film to overwrap products for containment using a power assisted pre-stretch mechanism with two pulling actions having a mechanical advantage over each other provides a significant improvement over the prior art. The pulling action elongates the film between the two rollers connected to rotate at different speeds and isolates the elongation action from the film roll and the pallet load. The mechanical advantage of the second pulling action over the first allows very high stretching levels to be achieved. The power assisted forces on the film result in some strain recovery because the yield point was exceeded and a significant reduction in film relaxation after stretch was obtained. It should be noted at this point that the yield point is substantially defined by the tensile yield of the stretch film being used. The tensile yield under ASTM Test Method D—882 for Mobil—X film is 980 psi; Mobil—H film 1000 psi; and Mobil—C film, 1000 psi. The force required to reach the yield point prior to stretching for a given film web is found by the formula:

$$\frac{\text{cross sectional area} \times \text{tensile yield}}{\text{equals force at yield point}}$$

As an example, the yield point of a 20" x .009 inch web of Mobil—X film would therefore be 17.6 pounds before it is pre-stretched.

The common tests used to determine tensile yield are the ASTM D—882 and ASTM D—8638.

These lower forces placed on the load allow the overwrapping of the product at very high levels of elongation without disruption or crushing forces which would be incurred at equivalent levels of elongation using conventional brake-type film stretch systems.

Figures 22, 24 and 25 are graphic depictions of the performance advantages obtained by using the present invention. Figure 23 depicts the balance point obtained with ROLLER STRETCH which is helpful in understanding the invention. The film used in obtaining the data for the graphs was Mobil—X.

Figure 22 illustrates the winding force exerted on film pulled by a rectangular load on a rotating turntable as a function of the angular position of the turntable. Curve 402 shows this function for the direct film web drive called ROLLER STRETCH, curve 404 shows the function for the power stretch embodiment, and curve 406 shows the function for the present invention. It is clear that the present invention combines the advantage of minimal variance in winding force as seen in the film drive embodiment with the advantage of

lower absolute winding force as seen in the power stretch embodiment.

Figure 23 illustrates the percentage of elongation between rollers as a function of the percentage of elongation of film applied to the palletized load in the ROLLER STRETCH embodiment. Line 410 is a 45 degree line, that is, one in which the elongation on the Y axis of the graph is precisely equal to the elongation on the X-axis of the graph. Curve 412 shows the actual performance of the film web drive embodiment. Point 414 shows the balance point between the two.

Figure 24 is a graphic depiction of the amount of power assist contributed by the positive constant torque device 40 as a function of the winding force applied to the palletized load. Each of the four curves shown correspond to a different gear ratio between the rollers 34 and 36. Curve 420 corresponds to a 102.2 gear ratio, curve 422 corresponds to a 140 gear ratio, curve 424 corresponds to a 200 gear ratio, and curve 426 corresponds to a 238.7 gear ratio.

Figure 25 depicts the amount of power assist provided to the rollers 34 and 36 by constant positive torque device 40 as a function of the force exerted on the load. It should be noted that the force exerted is the crushing force on the load.

It can be easily seen that the power assisted stretch enables film to be placed on a load at relatively low force which significantly increases after the passage of time. Thus, it is apparent that film relaxation is minimal. The four curves portrayed correspond as in Figure 24 to differing gear ratios between rollers 34 and 36. Curve 434 corresponds to a 102.2 gear ratio, curve 436 corresponds to a 140 gear ratio, curve 438 corresponds to a 200 gear ratio and curve 440 corresponds to a 238.7 gear ratio.

Commercial pallet loads differ significantly from those loads which are utilized by film companies in order to determine the laboratory stretch characteristics of their film. Real film wrapping applications are commercially applied to three different load configurations which are designated for convenience, into load profiles A, B and C. The A load profile is a substantially smooth surfaced load which has no puncture hazards and fits on or overhangs the pallet. The test profile of the A load is 36 inches x 36 inches frame with a nominal 2 to 4 inch board extension on one corner of one inch. The B load profile is an irregular shaped load with a puncture hazard up to three inches. The test profile of the B load is a 36 inch x 36 inch frame with a nominal 2 to 4 inch board extension on opposite corners of 2 to 3 inches. The C load profile is a random shaped load with a puncture hazard of over three inches. The test profile of the C load is a 36 inch x 36 inch frame with nominal 2 to 4 inch board extension on opposite corners of 4 inches and 5 inches.

Because of the tear characteristics of the film, it can be seen that different film types can be applied to different load profiles at various

percentages of stretch. A measure of how much a given film may be stretched over a given load is determined by the film's elasticity, tear resistance, puncture resistance and consistency. In this

5 regard, it should be generally noted that the type A load profile can utilize films of the highest percentage of stretch with the B profile allowing an intermediate amount of stretch and the C type profile having the lowest amount of stretch which
10 can be placed on the load. An example of the three load profiles is shown in Figure 26. For the purposes of this application, stretch wrapping films have also been characterized into different categories. These categories have been broken
15 down into type 1 films such as linear low density polyethylene; type 2 films such as ethylvinylacetate; polyvinylchloride and cast low density polyethylene, and type 3 films such as blown low density polyethylene. Commercial
20 examples of type 1 films are Bemis ST—80, Mobil—X and Presto SG—4; type 2 films are Consolidated Thermoplastics RS—50, Borden Resinit PS—26 and Mobil—C. Generally speaking, the type 1 films have a higher degree of
25 stretch over all three load profiles with the type 2 films having intermediate stretch over all load profiles, and the type 3 films having the lowest stretch over all load profiles.

A novel inventive packages load has been
30 developed by using the above noted method of wrapping. This load utilizes the delayed memory characteristics of film stretched past the yield point so that film within a period of three minutes after it is stretched around a load significantly
35 increases the force on the load thereby holding the load under more compression after it has been wrapped with a looser force. It is thus apparent that one can wrap a load with stretched film with one force and with a passage of time the
40 force will increase placing the load under much more compressive holding power utilizing one of the benefits of shrink wrap. Thus, a novel package is envisioned in which a spiral or full-web wrap is placed around the load at a first lower force with
45 the film then regaining initial memory after having been stretched past its yield point so that the containment force is increased on the load at least 10 percent and having the potential significant post-wrapping conformation through
50 five percent shrinkage. This phenomenon is more readily seen in the graph which is presented as Figure 25 in combination with Figure 24.

It should be noted that the steps of the wrapping process can be interchangeable without
55 departing from the scope of the invention. Furthermore, these steps can be interchanged and are equivalent.

In the foregoing description, the invention has been described with reference to a particular
60 preferred embodiment, although it is to be understood that the specific details shown are merely illustrative and the invention may be carried out in other ways without departing from the true spirit and scope of the appended claims.

65 Claims

1. A process of making a unitary package by wrapping a plurality of units with a stretched plastic material overwrap forming a unitary load comprising the steps of:

- 70 a. transporting a web of plastic film to a stretching means;
- b. elongating the film in the stretching means over its yield point, thereby gaining substantially in strength per cross-sectional area and modulus;
- 75 c. acting upon said elongated material with a force relieving means while wrapping said load; and
- d. relieving the force on the film web wrapped around the load by transmitting the speed
80 changes of the load surface through the film web to the relieving means to selectively speed up and slow down the film web keeping a relatively constant force and stretch level on the load.

2. A process of wrapping a load encompassing
85 irregular or crushable members with a plastic material having a stress strain recovery characteristic comprising the following steps:

- a. dispensing a plastic web through a pre-stretching device adapted to rapidly stretch the
90 plastic material substantially over its yield point;
- b. immediately relieving the majority of the stretching force from the plastic material;
- c. wrapping the load with stretched plastic material having said majority of stretch force
95 relieved; and
- d. allowing stress and strain recovery of the pre-stretched plastic material to increase load holding forces and conformation of the wrap to load irregularities.

3. A process as claimed in claim 2, wherein
100 said stress and strain memory of the plastic material stretched over its yield point increases the load holding force at least 20 percent over the load holding force initially placed on the load.

4. A process as claimed in claim 2 or 3,
105 wherein said stress and strain memory of the plastic material stretched over its yield point increases the load holding force at least 50 percent over the load holding force initially placed on the load.

5. A process as claimed in claim 2, 3 or 4,
110 wherein said stress and strain memory of the plastic material stretched over its yield point increases the holding force at least 100 percent over the load holding force initially placed on the load.

6. A process as claimed in any one of claims 2 to 5, wherein said plastic material is rapidly
120 elongated over its yield point between two rollers, spaced apart in range of 1/4 inch to 2 inches.

7. A process as claimed in any one of claims 2 to 6, wherein said plastic material is a linear low density polyethylene.

8. A process as claimed in any one of claims 2
125 to 6, wherein said plastic material is a polyvinylchloride.

9. A process as claimed in any one of claims 2 to 6, wherein said plastic material is an ethylvinylacetate.

10. A process of making a unitary package by wrapping a plurality of units with a stretched plastic film web overwrap to form a unitary packaged load comprising the steps of:
- a. placing a load on a support;
 - b. positioning a roll of stretchable plastic film web on a dispenser means adjacent to said support;
 - c. withdrawing a leading edge of said plastic film web from said dispenser means through a plastic film web pre-stretching means;
 - d. holding said plastic film web adjacent said load;
 - e. stretching said film web above its yield point in said pre-stretching means by rotating the load causing the film web to be pulled past at least two roller surfaces of said stretching means, said roller surfaces being interconnected so that they rotate at different speeds when driven by said film web, the downstream roller surface propelling the film web at a faster rate of speed than the upstream roller surface causing the film web to incur substantially all of its elongation between said roller surfaces;
 - f. applying a constant positive torque to the interconnected roller surfaces to reduce the stretch force to the load to a level below the force required to pre-stretch the film web; and
 - g. wrapping the load with more than one revolution of the previously elongated film web.
11. A process as claimed in claim 10 wherein the said film is elongated between the roller surfaces and the force is reduced on the plastic film web through inelastic strain recovery between the downstream roller assembly and the load.
12. A process as claimed in claim 10 or 11, wherein the plastic film is elongated above 50 percent of the elongation attained at its yield point before being wrapped about the load, and a constant positive torque is applied to the stretching means to reduce the stretch percentage of the plastic material from the stretching means to the load to a level below the stretch percentage achieved between the rollers.
13. A process as claimed in claim 10, 11 or 12, wherein the speed differential between said at least two interconnected roller surfaces is selectively increased until maximum stretch is achieved for the film; and the driving force of the film from the load is assisted with the positive constant torque device until the stretch force is reduced sufficiently to wrap the desired load profile.
14. A process as claimed in any one of claims 10 to 13, wherein said wrapping is a spiral wrap.
15. A process as claimed in any one of claims 10 to 13, wherein said wrapping is a full web wrap.
16. A process as claimed in any one of claims 10 to 15, wherein said wrapping is a roped material.
17. A process as claimed in any one of claims 10 to 16, wherein said wrapping is a tacky material.

18. A process as claimed in any one of claims 10 to 17, wherein said web of stretchable material is pulled through said roller surfaces by rotating said load when said roller surfaces are in an unconnected state and at least partially wrapping the load; and subsequently interconnecting the roller surfaces while the stretchable material is being pulled therethrough stretching said web by increasing the speed of said web past a downstream roller as compared with the speed of said web past an upstream roller to stretch it past its yield point.
19. A process as claimed in claim 18, wherein the roller surfaces are unconnected through at least 1/4 revolution of the load to place a portion of material on said load that is stretched less than its yield point.
20. A process as claimed in claim 18, wherein the roller surfaces are unconnected through at least 1/4 revolution of the load to place a portion of material on said load that is substantially unstretched.
21. A process of making a unitary package by wrapping a plurality of units with a stretched plastic film web overwrap to form a unitary packaged load comprising the steps of:
- a. placing a load on a support;
 - b. positioning a roll of stretchable plastic film web on a dispenser means adjacent to said support;
 - c. withdrawing a leading edge of said plastic film web from said dispenser means through a plastic film web pre-stretching means;
 - d. holding said plastic film web adjacent said load;
 - e. stretching said film web above its yield point in said pre-stretching means by rotating the load;
 - f. applying a constant positive torque assistance to reduce the stretch force to at least 50 percent on the film from the pre-stretching means to the load to a level substantially below the force achieved within the pre-stretch device; and
 - g. wrapping the load with elongated film whose dwell time between the pre-stretching means and the load is less than one half second and which travels at a speed of at least 100 linear feet per minute.
22. A process as claimed in claim 21 including the step of allowing inelastic recovery to take place in the film between the pre-stretching means and the rotating load, thereby reducing the force required to carry the stretched film between the stretching means and the load.
23. A process as claimed in claim 21 or 22, wherein the film is stretched between connected rollers of said pre-stretched means over the film's yield point thereby gaining substantially in strength per cross-sectional area and modulus.
24. An apparatus for making a unitary package from a plurality of units forming a load using a web of stretchable plastic material to form the overwrap comprising a frame, plastic material dispensing means mounted to said frame, means to pull said plastic material from said material dispensing means, material elongation means

positioned between said dispensing means and said load, said material elongation means being adapted to receive plastic material pulled from said dispenser means and elongate the stretchable plastic material beyond its yield point and means to reduce the stretch force of the material on the load, to a level equal to or less than the force required to stretch the material web.

25. An apparatus as claimed in claim 24 wherein said elongation means comprises at least two connected and closely spaced apart rollers.

26. An apparatus as claimed in claim 25 wherein said rollers are connected by gears sized to achieve a mechanical advantage.

27. An apparatus as claimed in claim 25 or 26, wherein said space between the two connected rollers ranges from 1/4 inch to 2 inches.

28. An apparatus as claimed in claim 25 or 26, wherein said space between the two connected rollers does not exceed 7 inches.

29. An apparatus as claimed in any one of claims 24 to 28, wherein said means to reduce the stretch force is an air motor assembly.

30. An apparatus as claimed in claim 29, wherein said motor assembly comprises a shaft, an air motor mounted to said shaft and adapted to drive said shaft, a source of air pressure communicating with the driving said air motor, a reduction means mounted to said shaft and a spur gear connected to said reduction means.

31. An apparatus as claimed in any one of claims 24 to 30, wherein said elongation means comprises at least two connected and closely spaced apart rotatable rollers, said rollers being connected by gear means, clutch means mounted to said gear means and adapted to selectively allow said gear means to positively engage the rollers together and including a constant positive torque producing means connected to said gear means and means to power said torque producing means.

32. An apparatus as claimed in claim 31, wherein said powering means is a source of pressurized air.

33. An apparatus as claimed in any one of claims 24 to 32, wherein said elongation means restricts said plastic material after it has been dispensed from the dispenser means and the material web is pulled from the dispenser means through the elongation means by rotating turntable so that a downstream portion of the material web is transported faster than the upstream portion causing the material web to elongate before it reaches the load, said elongation means comprising a roller means including a positive torque means for applying a constant positive torque to said roller means to reduce the stretch force on the load to a level equal to or less than the force required to pre-stretch the material web.

34. An apparatus for making a unitary package from a plurality of units forming a load using a web of stretchable plastic material to form the overwrap comprising a frame, a plastic material

dispensing means mounted to said frame, elongation means mounted to said frame adapted to receive stretchable material pulled from said dispenser means and elongate the material beyond its yield point, said elongation means comprising at least two connected and closely spaced apart rollers driven by the material web pulled from the dispenser means so that the downstream roller transports the material web faster than the upstream roller to cause the material to elongate before it reaches the load, and powered torque assistance means connected to at least one of said rollers, said powered torque assistance means applying a constant positive torque to said rollers to reduce the stretch force on the load to a level equal to or less than the force required to stretch the material web.

35. An apparatus as claimed in claim 34 wherein the constant positive torque applied to said rollers is less than or equal to $(F_1 - F_2) \times \text{mechanical advantage}$.

36. An apparatus as claimed in claim 34 or 35, wherein said rollers are spaced in a range of 1/4 inch to 2 inches.

37. An apparatus as claimed in any one of claims 34 to 36, wherein said elongation means comprising at least two connected and closely spaced apart rollers is driven by the material web pulled from the dispenser means by a rotating turntable, which in conjunction with the pallet and load acts as a film mandrel.

38. An apparatus as claimed in any one of claims 34 to 37, wherein a carriage is moveably mounted on said frame and said dispenser means is mounted to said carriage, and including a rotatable turntable adapted to receive and support said load, drive means connected to said turntable and adapted to rotate said turntable and said associated load placed on said turntable, said elongation means being connected to said carriage and adapted to receive stretchable material pulled from said dispenser means, said powered torque means applying a constant positive torque to said rollers to reduce the stretch force on the load to a level equal to or less than the force required to pre-stretch the film, and means to drive said carriage reciprocally along said frame so a plurality of overlapping layers of elongated material are placed on said load to form a wrapped tensioned unitary package, said carriage being driven along the frame in one direction to provide an overlapping spiral wrap for the load and returning in an opposite direction while continuing to wrap the load with an overlapping spiral wrap.

39. An apparatus for making a unitary package by overwrapping a plurality of units forming a load with a single strand of stretchable plastic material comprising a frame, a carriage moveably mounted on track means defined by said frame for movement along said frame, said carriage comprising a support structure, a rotatable roller of stretchable plastic material mounted to said carriage and pre-stretching means connected to said carriage, a rotatable turntable positioned

- adjacent to said frame adapted to support a load comprising a plurality of units, drive means connected to said turntable and adapted to rotate said turntable and the associated load placed on said turntable to wrap said load with pre-stretched material from said pre-stretching means, said pre-stretching means substantially stretching said stretchable plastic material above the yield point, said pre-stretching means comprising roller means which engage the material web across its width, said roller means being driven by the film web pulled from the dispenser roll by the rotating turntable and comprising at least one roller member located upstream from at least one other roller member in relation to the material web being dispensed from the material roll, said at least one roller member transporting the material web at a slower speed than the web being transported downstream causing the web to elongate past its yield point, a positive torque device connected to said roller means, said positive torque device being driven

- by pressurized air of a predetermined pressure relieving the stretch forces required to drive said roller means allowing inelastic strain recovery to take place between the pre-stretching device and the load thereby reducing the force required to carry the stretch film between the pre-stretch device and the load, said carriage being driven along the frame in one direction to provide an overlapping spiral configured wrap for the load surface and returning in an opposite direction to provide an overlapping spiral configured wrap on the surface of the load and roping means engaging said elongated web to rope and tie the web to the load.

40. A process for making a vintory package substantially as hereinbefore described with reference to and as illustrated in any one or more of Figs. 6 to 34 of the accompanying drawings.

41. An apparatus for making a vintory package substantially as hereinbefore described with reference to and as illustrated in any one or more of Figs. 6 to 34 of the accompanying drawings.